MEANING AND LEARNING

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By

Barry Cartwright Munro

1959

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THE UNIVERSITY OF ALBERTA

MEANING AND LEARNING

A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATE

STUDIES IN PARTIAL FULFILMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DIVISION OF EDUCATIONAL PSYCHOLOGY

by

BARRY CARTWRIGHT MUNRO

EDMONTON, ALBERTA

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ABSTRACT

The principal purpose of this investigation was to determine the learning outcomes resulting from the use of three methods of study arranged in ascending order of meaningfulness. To achieve this purpose an experiment was conducted in twelve selected grade seven classrooms of the junior high schools of the Edmonton Public and Separate School systems.

In the investigation, the differential effects of three instructional procedures upon learning in three subject-matter areas were studied. The three methods involved the study of material for facts, the study of material to determine the significant relationships that existed within it, and the study of material to determine the major generalizations that might arise from it. The effects of the varied methods were ascertained by measuring the amount of material learned, the amount retained after an interval of twenty-one days, and the degree to which the effects of training in a particular method were transferred to other situations. The three subject-matter areas considered in this experiment were mathematics, science and social studies.

The twelve classrooms taking part in the experiment were divided into three subject-matter groups, each composed of three experimental classes and one control. Each experimental class was randomly assigned a particular method of study to be followed throughout the investigation and received four thirty-five minute instructional periods in each of two subject-matter fields.

Selected bodies of subject matter, suitable to the level of experience of the students involved and related to the grade seven course of studies in mathematics, science and social studies, served as learning materials for the testing program. Three multiple-choice tests, similar in structure and equated in degree of difficulty were designed to accompany the learning materials and serve as pre-tests, post-tests and transfer tests. In addition to these, the Otis Quick-Scoring Test of Mental Abilities, Beta Test, was given to each of the classes. Retention after a three-week interval was measured by a second administration of the post-test in each group.

Since it was not possible to match the groups prior to the beginning of the experiment, they were equated statistically during the analysis of the results, on the basis of mental ability and experience in the methods of study employed in the experiment. To do this, analysis of covariance was used with mental age and pre-test scores held constant. Where equating was not necessary, analysis of variance was employed to investigate mean differences.

The analysis of the data obtained from the twelve grade seven classes revealed the following:

1. In the majority of cases, the three methods of study employed in this experiment were equally effective in producing gains in learning as measured by the difference between scores on the pre-test and the post-test. Where differences in gains occurred, however, the more meaningful methods of study were favored over the less meaningful methods.

2. Within the same subject-matter area, the effects of training in the more meaningful methods of study, those of generalization and relationship, appeared to be transferred to a greater extent than did the effects of training in a less meaningful method, that of facts.
3. There was no indication that training in one method of study produced greater retention of material after an interval of twenty-one days than did training in any other method of study employed in this investigation.

On the whole, where significant differences were obtained, results generally favored the more meaningful approach to learning. For the most part the Generalization group was found to have made significantly higher scores than the Fact group. There were, however, a number of instances in which the Generalization group was superior to the Relationship group, and also a number in which the Relationship group made higher scores than the Fact group. The total picture suggested by these results is a gradient of meaningfulness of methods of study beginning with the lowest level, the study of facts, and extending through the study of relationships to the highest level, the study of generalizations.

Although there were indications that learning with meaning has been incorporated into the modern classroom, the failure of the Control group to achieve as well as the Generalization group would suggest that learning with meaning has not reached its maximum in current educational practice. Possibly greater emphasis should be

given to the development of the ability to read for generalizations than is presently the case. Since habits associated with methods of study seemed to be resistant to change by the grade seven level, it would likely be best to initiate this attention to the development of the ability to read for generalizations early in the school program. If, however, changes in methods of study must be made in the later grades, it appears that considerably more extensive training would be required than was employed in the present investigation.

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CHAPTER I

MEANING AND LEARNING

Recently, in education, considerable attention has been focused on the value of meaning in learning. In increasing numbers, teachers have come to realize that if desirable outcomes of learning in terms of retention and transfer are to be achieved, the experiences encountered in the classroom must have meaning for the pupil.

With reference to the nature of meaning, Babcock states that it "... denotes psychological insight, the spontaneous perception of essential relationships in social and environmental contexts by a complex ... process called thinking" (1948, p.398). The raw material from which complete meanings are constructed is sense perception. The primary stage in this development consists of identifying objects, naming them and acquiring definite modes of adjustment to them. A secondary phase of the development of meaning arises when one object or event points to or signifies more than is perceived immediately (Griffith, 1939). The second stage is most important according to Cohen, who observes that "... anything acquires meaning if it is connected with, or indicates, or refers to something beyond itself, so that its full nature points to and is revealed in that connection" (1944, p.47). This is essentially Brownell's point of view (1945) when he suggests that meaning is related to the structure and organization of the subject itself.

Many psychologists, on the other hand, do not consider the material to be the only factor influencing the development of meaning. They are

inclined to agree with Bernard (1954) who maintains that meaning always has reference to the individual. Things acquire meaning when they are "... related to the individual's interests, when they are involved in his living and when they not only contribute to his purpose at the time, but enable him to make more intelligent adjustments in the future ..." (Gates, Jersild, McConnell, and Challman, 1949).

In a discussion of ideational learning, Brownell and Hendrickson (1950) postulate a continuum of meaningfulness for facts and concepts ranging from the level of unrelated facts or arbitrary associations to the level of the development of explanatory principles and generalizations. They note, in addition, that a given fact cannot be assigned an absolute position on the continuum, but that its meaning depends upon the individual who is involved in the learning task.

Cronbach (1954) suggests that a concept has meaning for an individual when it is consistently applied to some situationsand not to others. This idea implies agreement with Spitzer who stated that "meaning is the seeing of reasons for, the import of, or the sense of, a process" (1948, p.14). A further test of meaning is given by Davis (1948); namely, the ease with which the learner makes progress in the learning situation and the extent to which he can understand new facts.

There are factors within the individual, of course, which limit the number of understandings he may acquire and the degree to which they may be mastered. Within the capacity of the individual learner, however, the nature of the learning situation determines to a large extent the amount of meaning he associates with his experience.

Brownell and Sims (1946) state that the development of meaning

is facilitated if the individual is motivated initially by a recognized need. Also, the learner must possess a background of experiences relevant to a new situation. Understanding increases, they maintain further, when a pupil formulates the results of his learnings in his own words and in a variety of ways. In developing meanings, then, from their point of view, the learning situation must be characterized by activity on the part of the student, not by the passive acceptance of the teacher's word.

According to Davis (1948) facts known in isolation cannot yield full meaning until their roles as parts in a total picture are made clear. He believes that the establishment of meaningful learning situations requires the development of a plan of learning, stress upon meaning for the learner and effective relating of wholes and parts.

In discussing meaningful learning situations, Theile (1951) emphasizes the role played by the student. He feels that each student should make a contribution to the learning process. Teachers in such a situation can no longer rely on prescribing material, identifying adequate responses and striving for mastery by repetition, but must concern themselves with broader patterns of behavior. They must seek active pupil participation in learning, and they must endeavour to make thinking a dominant part of the learning period.

Both Theile (1951) and Horn (1951) point out that students may be stimulated and guided in the construction of meanings, but that they cannot be given them. Teachers may create situations or bring

about conditions that help children gain meaning, but in the last analysis, meanings must be discovered by the children themselves. Horn mentions further that the effectiveness of the development of meaning in the learning situation depends upon the student's experience, interest, intelligence, command of the language skill and the efficiency of his work habits.

Hopkins (1955) observes that many meanings developed by children are from second-hand experiences and as a result are cloudy meanings. He feels, then, that children need assistance in clarifying their meanings and that to build better meanings they must be free to express, without fear of oppression, those concepts which they accept. A feeling of security in the process of building better meanings is vital as it leads to open mindedness, tolerance and intelligent change. Many teachers, in his opinion, lose the opportunity to better the meanings of their pupils through a failure to develop feelings of security within the class.

In considering the value of learning with meaning, Douglas and Spitzer (1946) state that understanding influences both the range and quality of the adjustments of the individual. Without meaning, they note, a pupil may react only to familiar situations and in a routine manner. In commenting on the same point, Fransden (1957) observes that emphasizing meaning in learning has two main advantages: it utilizes the concepts and principles achieved through the individual's past experience, and it consolidates numerous separate learnings into a smaller number of unifying principles.

Advantages of learning with meaning have been experimentally

determined on many occasions. In the discussion of his experiments on memorizing and forgetting, Ebbinghaus (1913) stated that meaningful material is more easily fixated, and better retained than nonsense material. More recent writers (Deese,1948; Miller and Selfridge,1950) agree with this finding and suggest that the reason for this is that meaningful materials contain a number of short phrases that go together and that these short range associations are familiar to the learners.

Hildreth (1942) studied problem solving with children in grades two, three and four and found that solutions were obtained faster and more easily when a meaningful approach was used than when the problems were attempted in a blind mechanical fashion. McGeogh and Irwin (1952) concur in this finding and state further that the greater effectiveness of the meaningful over the rote method suggests that learning requires an active, analytical mode of response on the part of the pupil.

Brownell and Moser (1949) reported that teaching subtraction by a meaningful decomposition method produced greater transfer and retention than either decomposition taught mechanically or the equal addition method taught mechanically or in a meaningful manner. They felt that the meaningful decomposition method was successful because it was understood by the pupils involved in the experiment, while the other methods were not.

A general conclusion offered by Swenson (1949) was that a significant advantage in learning appeared to be associated with a method of study that stressed the organization of number facts about pupil-discovered generalizations. This method, it may be noted, was the most meaningful of those used in the study.

Another finding that confirms the idea that there is an advantage in learning through the meaningful approach is reported by Stacey who noted that "the learner obtains as many or more facts and discovers more correct reasons for them, by a process of self-discovery than by a process of authoritative identification" (1949, p.101).

Brownell (1928) found that children's success in learning the simple addition combinations was closely related to the completeness of their concepts of numbers, that is, to the meaning that numbers had for them.

The value of a meaningful approach to learning is well summarized by Reid (1938). In discussing the results of his investigation he noted:

> ...the advantage of the perception of meaning is that it contains the secret of economical learning. This means that in order to learn easily, retain well and transfer skill effectively, we should emphasize the importance of the perception of meanings, relationships, and principles (1938, p.422).

While many opinions have been expressed favoring a meaningful approach to learning, and a considerable body of research lends support to these opinions, the method has not, as yet, been adopted universally. Perhaps generalizations have been made from experiments involving nonsense materials that have not been borne out in meaningful situations. It may be that the results of experimentation are relevant only when restricted to the grades and subjects involved in a particular study, and cannot be applied to learning situations generally. Regardless of the cause of the lack of acceptance, however, it appears that further information must be obtained on the relationship between meaning and learning if one is to expect a change in existing practices in education.

CHAPTER II

THE PROPOSED STUDY

General Statement

The principal purpose of this investigation was to determine the learning outcomes resulting from the study of classroom material using methods arranged in an ascending order of meaningfulness. To achieve this purpose, an experiment was conducted in selected grade seven classrooms of the junior high schools of the Edmonton Separate School system and the Edmonton Public School system.

In the investigation, the differential effects of three instructional procedures upon learning in three subject matter areas were studied. The three methods involve the study of material for facts, the study of material to determine the important relationships that exist within it, and the study of material to determine the major generalizations that may be made from it. The effects of the varied methods were determined by measuring the amount of material learned, the amount retained after a three-week interval, and the degree to which the effects of a particular method were transferred to other situations. The three subject-matter areas considered in this experiment were mathematics, science, and social studies.

Importance of the Study

In our society educators are faced with the increased pressures of greater numbers of students in the schools, coupled with demands for better and more extensive training. Much of this pressure is due to

our rapidly increasing technological development with its demand for more highly trained personnel. Some, also, stems from unfavorable comparisons of the products of our educational system with those of other nations. Regardless of the source, however, it is the efficiency of our educational system that is being questioned.

It seems appropriate, then, that where possible, investigations should be carried forward that may lead to further understanding of the learning process, enabling modifications to be made where necessary to meet present demands on education. Investigations of this nature, aiming at practical findings, would seem to be best conducted within the present system, and, as nearly as possible, under ordinary classroom conditions. The results of such research should prove to be more readily translated into classroom practice than results achieved from smaller laboratory projects, valuable though these may be.

Many experiments have been undertaken to compare the relative efficiency of learning by various methods and to determine the amount of retention and degree of transfer associated with these methods. Few of the existing studies, however, endeavor to examine all these factors within the same experimental framework, nor do they attempt comparisons between various subject-matter areas. In addition, many experimenters have generalized findings from research involving nonsense materials and arbitrary relationships, quite unlike the material of the average classroom.

The decision to include in this experiment actual classroom material in three subject matter areas as well as to investigate the influence of three methods of study on learning, transfer and retention

should prove of value in several ways. It will, first, allow an examination of existing points of view in a new situation. Secondly, generalizations on learning may be broadened in their scope and made more widely applicable. Third, the results should be in a form that is meaningful to the teacher, and hence be more readily applied in the classroom.

The Scope of the Study

Population to be Used

To make the results of this investigation as valuable as possible for the practicing teacher it was decided that the unit for study should be the actual classroom. While any grades of the school system may serve as an adequate site for an investigation of this kind, it was decided to concentrate at a point where the students would have sufficient experience to be able to make effective generalizations and at the same time not have reached the period of specialization in study that is found in the high school.

The pupils of the seventh grade were thought to meet these criteria sufficiently to serve as the experimental group. In addition, this group met another practical requirement in that grade seven students are not required to write departmental examinations at the end of the term, a fact which would have seriously affected the attitude of the teaching staff toward the experiment had it been conducted at the grade nine or grade twelve levels.

Delimitation of the Area of Investigation

Methods. It is possible to envision a continuum of meaningfulness

of material to be studied in a classroom extending from the level of unrelated facts, or arbitrary associations, to the level of the development of explanatory principles and generalizations (Brownell and Hendrickson, 1950). At the same time there are a number of methods of studying material which differ in meaningfulness for the learner. These range from drill, in which meaning may be at a minimum, through various stages of guided learning to the most meaningful method of study, that of pupil-discovery and verification. The combinations of methods and materials of varying degrees of meaning become so numerous that their investigation in a single experiment would not be possible.

In an effort to ascertain some of the relationships between meaning and learning it was decided to limit to three the methods of study to be used in this investigation. The three methods of study, capable of separation by careful definition, were: first, the study of a body of subject matter to determine the significant facts in it, second, the study of a body of subject matter to determine the important relationships that exist within it, and third, the study of a body of subject matter to determine the major generalizations that might be made from it.

Subject Matter. If one can make generalizations concerning the processes of learning, retention and transfer, it would seem that any material suited to the level of experience of the learners would serve adequately as material in an investigation such as this. Again, however, with the aim in mind on making the results more directly applicable to the classroom itself, it was decided to use materials that form part of the content of courses actually being taught in the

schools.

Because a comparison of the effects of the different methods of study in various subject matter areas was desired, the decision was reached to include material from mathematics, science and social studies. The only restriction placed on the material to be studied was that it had not been discussed in class before the time of the investigation.

Classes. Because of the need for extensive classroom time for an investigation of this kind, an attempt was made to operate with the minimum number of classes that would permit the fulfillment of the purposes of the study. To make the experiment administratively simpler and to allow the experimenter to conduct all training periods orally, a particular method of study was assigned to a complete classroom. The investigation of one subject-matter area would, then, require three classrooms, one for each of the three methods of study.

In order to compare the effectiveness of the methods of study in different subject-matter areas and at the same time not deprive a class of too much of its regular instruction, it was decided to limit each class to a study of two kinds of subject-matter. This resulted in the experiment requiring a total of nine experimental classes. An additional three classes were added to serve as control groups.

Time. It would seem likely that, regardless of the method of study employed, the greater the time spent in training the students, the greater the chance of the application of the method in later situations. A pilot study conducted by the experimenter in June, 1957, suggested

that intensive study of material by the methods proposed for this investigation might be effectively carried out for four or five thirty-five minute periods over four or five days. Beyond that time it seemed that there was a loss in motivation, particularly in the group restricted to the study of the facts in a selection. With this in mind, and also to complete the training periods before the Christmas vacation, a four-period training plan was accepted.

Selection of Classes

Since a total of twelve classrooms was to be involved in this study, both the Edmonton Public School Board and the Edmonton Separate School Board were approached to secure their co-operation in the project. The principals and staffs of five schools in the Edmonton Separate School system, interested in the study, provided six of the required classrooms. The six additional classes were made available to the experimenter in one large junior high school in the Edmonton Public School system. Altogether there were 386 students involved in the experiment.

Definition of Terms

For the purposes of this study, the term "fact" will be taken to mean anything that is known to exist or is accepted as being true without consideration of supporting evidence.

"Relationships" will emphasize the connection, correspondence or contrast that exists between persons or things. More specifically, the term will be restricted to cause and effect, temporal or spatial relationships, and similarities and differences.

The term "generalization" will refer to general inferences that

may be made from the subject matter studied in the experiment. It will include the derivation or induction of general principles or general conceptions. These generalizations would have application in the area of the material read, although they may be applied more broadly.

Summary

Three kinds of learning activity were employed in this study. These were: the study of material for facts, for relationships, and for generalizations.

Because there might be differences in the ease with which learning outcomes are achieved in the various subject matter areas, three sets of material were assembled, covering the fields of mathematics, science and social studies. Each class was given two sets of materials, thus allowing comparisons to be made between the kinds of material studied and the various learning outcomes. As well, comparisons could be made between the kinds of learning activity and their results.

Twelve classrooms were used in the investigation, nine serving as experimental groups and three as controls.

Basic Assumptions

Before undertaking an investigation of this kind, certain basic assumptions had to be made. First, it was necessary to accept the assumption that there is a relationship between the meaning that the material or method of study has for the individual and the amount of learning, the extent of retention and the degree of transfer.

A second assumption was that the methods of study employed in the

experiment were sufficiently distinct to produce measurable differences in the outcomes of the learning situation.

It was also necessary to assume that the tests employed in determining the effects of the different methods of study were sufficiently well constructed to measure these effects adequately.

A fourth assumption was that there were available techniques of analysis that would allow the assessment of the extent and direction of differences in performance that appear from the testing program. In this instance, the techniques of analysis of variance and covariance were selected as being most appropriate.

Subdivisions of the Main Problem

In order to fulfill the purpose of the experiment, it was necessary to subdivide the main problem for the analysis of the data. The following questions represent the major areas of investigation:

1. Does training through any one of the methods employed in this investigation, namely, the study of material for facts, for relationships, and for generalizations, tend to produce greater gains in learning than result through training in any of the other methods?
2. Does training through one particular method of study produce comparable gains in other learning outcomes? For example does practice in the development of generalizations based on a body of subject matter produce improvement in the learning of facts and the developing of relationships?
3. Does training through one particular method of study yield

greater evidence of transfer to new material within the same subject matter area than does training through another method?

4. Within the given subject matter field, is the amount of transfer associated with a particular method comparable for the areas of fact, relationship and generalization?
5. Do the effects of training through one particular method of study appear to be transferred from one subject matter area to another to a greater extent than the effects of training through another method?
6. Is the amount of transfer associated with a particular method of study comparable in the areas of fact, relationship, and generalization?
7. Does training through one particular method of study produce greater retention than through either of the two other methods?
8. Does training through one particular method of study produce comparable retention of facts, relationships and generalizations? For example, does training in the method of studying material for generalizations result merely in the retention of generalizations, or are other learning outcomes retained as well?

These questions were translated into hypotheses to be tested. The experimental and statistical design used in their testing is discussed in detail in Chapter Five.

CHAPTER III

RELATED STUDIES

An attempt will be made in this chapter to present certain theoretical points of view related to this study and to summarize existing research supporting these views. As much as possible, the discussion will center about theory and research that has been most closely related to classroom practice. It is felt that a review of this nature will prove of value in the interpretation of the results of the present experiment.

Learning

While recognizing that it is extremely difficult to formulate an acceptable definition of learning, Hilgard suggests the following:

> Learning is the process by which an activity originates or is changed through reacting to an encountered situation, provided that the characteristics of the change in activity cannot be explained on the basis of native response, tendencies, maturation, or temporary states of the organism (e.g. fatigue, drugs, etc.) (1950,p.3).

Attempts to explain the nature of learning, he continues, fall into two broad categories, stimulus-response theories on the one hand, and cognitive theories on the other. The lines of separation between theories, however, are not always sharp. There may be areas of agreement between members of opposing groups as well as areas of difference between those of the same general category.

Some basic differences between theorists in these two groups may be seen through a consideration of three main points: (a) the stimulus-response theorist prefers to find peripheral machanisms to integrate

sequences of behavior, that is, he is interested in movement and what the individual does, while the cognitive theorist utilizes central or ideational intermediaries, using such things as memories and expectations as integrators of goal-seeking behavior, (b) the stimulus-response theorist maintains that what is learned is habit or response; the field theorist believes that it is a cognitive structure that is learned, (c) trial and error is the characteristic form of learning for the stimulus-response theorist, while the cognitive theorist feels that insight, that is, the understanding of the relationships involved in a situation, plays an important part in learning.

Each of the systematic approaches to the understanding of learning has contributed to existing knowledge concerning the problem. But, Hilgard cautions:

> At the same time, no one has succeeded in providing a system invulnerable to criticism. The construction of a fully satisfactory theory of learning is likely to remain for a long time an unaccomplished task (1956,p.14).

Transfer of Training

Transfer of training, broadly speaking, refers to instances where learning in one situation affects, in some way, the individual's performance in another, somewhat different situation.

An early point of view which offered an explanation of transfer was known as the theory of formal discipline. This idea was based on the principles of faculty psychology in which the mind was considered to have a number of faculties such as memory, reason, the will, attention, and the like. Each faculty was thought to operate

independently and each could be improved with practice. Transfer, from this point of view, came about automatically. Drill in geometry, for example, was believed to improve the reasoning ability of the individual in all areas.

Many psychologists were not satisfied with this explanation, and attempted to clarify the situation by experimentation. One of the earliest studies was that undertaken by Thorndike in 1924, in which he studied the influence of training in particular subject areas in the high school on performance on a series of reasoning tests. About 13,500 high school students were involved in the investigation. He concluded that:

> By any reasonable interpretation of the results, the intellectual values of studies should be determined largely by the special information, habits, interests, attitudes and ideals which they demonstrably produce. The expectation of any large differences in general improvement of the mind from one study rather than another seems doomed to disappointment... After positive correlation of gain with initial ability is allowed for, the balance in favor of any study is certainly not large (1924,p.98).

As experimental evidence opposing formal discipline accumulated, it became evident that practice did not bring about automatic improvement in all aspects of a mental operation. A question then arose concerning the degree to which training in one area was effective in improving or aiding operations in a second area.

According to Thorndike, this phenomenon could be explained by determining the number of common elements in the two situations. He expressed this point of view, known as the theory of identical elements, as follows:

> The answer which I shall try to defend is that a change in one function alters any other only in so far as the two functions have, as factors, identical elements. The change in the second function is in amount that due to the change in the elements common to it

> and the first. The change is simply the necessary result upon the second function of the alteration of those of its factors which were elements of the first function, and so were altered by its training (1913,p.358).

Because the term "element" became generally taken to mean something indivisible or atomistic, Wood worth (1938) suggested that the term "component" be substituted. This broadened the scope of the theory so that a fact, procedure or attitude, learned in one situation, could be made to operate in another similar situation.

Another, and somewhat different idea of transfer was expressed by Charles Judd (1939). As a result of experimentation, he concluded that the essence of transfer is found in generalization - the ability to apply broad principles and meanings to specific situations. According to this theory, understanding of experience, its organization into patterns and its relations to other situations should be stressed in learning, if transfer is to take place.

Although transfer of training is not discussed by gestalt psychologists, their concept of transposition, according to Hilgard (1956), is similar to transfer. This is essentially the application of perceived relationships to other suitable situations. Hilgard notes: "there is something in common between the earlier learning and the situation in which transfer is found, but what exists in common is not identical, perceived elements, but common patterns, configuration or relationships." (1956,p.252). This idea is not unlike that expressed by Judd, but Katona (1940) states that generalization in itself is not sufficient for transfer. The effect is produced only by structurally adequate generalizations which bring adequate, meaningful organization to the situation.

Referring to the mechanisms by which transfer takes place, Stephens observes:

> A large part of the controversy has been between the proponents of the identical elements theory of Thorndike and the generalizations theory of Judd. This argument is rapidly coming to have merely historical importance, since it becomes more and more evident that the contrast between the two theories is not very clearly drawn (1951,p.467).

A consideration of research findings, rather than the theoretical points of view may be of greater value in understanding the phenomenon of transfer.

The influence of method of study on transfer has received attention from psychologists for some time. Woodrow (1927) investigated the relationships between transfer and method of learning to memorize. One experimental group merely practised memorizing passages; a second experimental group received specific training in how to memorize; a third group served as a control. It was found that with undirected drill, indications of transfer were generally small, either positive or negative, but that the group receiving some training in method of study exhibited considerable positive transfer.

In another early experiment, Overman (1930) attempted to measure the transfer effects of instruction given in three methods of teaching addition. He had a Generalizations group, which formulated general methods or procedures, a Rationalization group, in which reasons and principles were discussed, and a third group for which these two approaches were combined. Working with grade two pupils, it was found that the Generalization group was superior in transfer tests, followed by the Combined group and then the Rationalization group.

A more recent study by Swenson (1949) tends to substantiate these

findings. Working with three groups of grade two pupils, and using one hundred addition facts as material, she found that the group taught to organize addition facts around number generalizations was superior to a drill-plus-verification group and a drill group.

Essentially the same results had been reported by McConnell (1941). He gave four transfer tests to two groups of second grade pupils. One group had been taught by methods that were confined to specific drill on the basic addition and subtraction facts, and the other had been given instruction that emphasized the meaning and interrelationships of the combinations. The latter group was superior to the drill group on all four tests.

Theile's experiment (1939) also indicated that a more meaningful method of study, that of discovery and verification, produced superior transfer when compared with a method that emphasized drill without understanding.

In 1941, Hendrickson and Schroeder repeated Judd's classic experiment involving the submerged target, with an air gun in place of the darts originally used. They found that knowledge of theory facilitated transfer, confirming the findings of the earlier experiment. They found, in addition, that theoretical information was an aid in making the original adjustment to the first situation, a finding in contrast to that of Judd and Scholckow.

Katona (1940), in his study of retention and transfer, noted that, contrary to the views of the proponents of the theory of identical elements, transfer would take place when learning was accompanied by understanding whether the elements of the new situation were more or

less similar to the old situation.

In stressing the significance of learning with understanding he stated further:

> With meaningful learning ... we find that there is a plasticity or flexibility of learning which permits reasonable applications in a wide scale. These applications are due, not to the transfer of specific data from an A to a B, but to the fact that meaningful learning results from the acquisition of integrated knowledge, which is usable under different circumstances (1940,p.136).

An extension of the experimentation of Katona by Hilgard and his associates (1953) verifies the earlier findings. In this experiment, learning with understanding produced transfer, both in simple and complex situations, in greater amounts than did learning by memorization.

That attitudes of the learner are significant in transfer is noted by Dorsey and Hopkins (1930). By building up in their experimental groups a "readiness to act", they found superiority in this group over a control group in transfer of method of a study, transfer of skills and transfer of knowledge. Because the groups were equated in intelligence and both received the same preliminary instructions, the experimenters felt that the difference in performance was due to something other than these and suggested the attitude of readiness as the cause.

The kind of instruction given pupils also appears to influence the amount of transfer obtained. Salisbury (1934) observed that training in the conscious use of outlining, which stressed organization and hence understanding of material, tended to improve the mastery of content subjects. Gatchel (1931) concluded from his research that it was possible to train pupils in methods of study and that such training carried over into a variety of subjects.

It was noted by Barlow that "where training was devoted to instructions in abstracting, analyzing and generalizing, a relatively large amount of transfer resulted" (1937,p.127). Somewhat similar results are reported by Anderson (1949) who found that in mathematics, procedures emphasizing relational learning, discovery and generalization were more productive in both learning and transfer.

A recent investigation was reported by Kitell (1947) in which each of three groups of sixth-grade pupils was supplied with a different amount of direction during discovery of principles determining the solution of multiple-choice verbal items. He concluded that furnishing learners with information in the form of underlying principles promotes transfer and retention.

In summarizing the research reported, it appears that the most common conclusion concerning transfer of training is that transfer is facilitated by emphasis on understanding in the learning process. Methods of study stressing the importance of generalization, and specific techniques that require analysis and organization of the material seem to bring about the highest degree of transfer. In other words, the more meaningful the situation is for the learner the greater will be the amount transferred to new situations.

Retention

An early point of view concerning forgetting was found in Thorndike's Law of Exercise. This states that connections are strengthened when practised and tend to weaken when practice is stopped. Thus it appears that the passage of time is the major factor in forgetting. Although

Thorndike later withdrew emphasis from this statement as a law of learning, its influence has not altogether disappeared from people's thinking.

The concept of memory trace was advanced by Koffka in an attempt to explain the influence of the past by the condition of the present. He states:

> In this explanation of memory events, an event in time influences another event, which succeeds it after a finite interval, not directly, but only through some effect which it has left behind and which for brevity's sake we shall call a trace ... (1935,p.429).

Hilgard (1956) notes that in addition to the trace, something that goes on because of a present stimulating situation called a present process, must also be postulated. This present process can select, reactivate or in some way communicate with the trace, resulting in recognition or recall. The process and the trace are distinguishable in that they are localized in different parts of the brain. The entire trace system is considered to be organized according to the same gestalt laws as are applied in other fields.

Of all the changes in the trace system, forgetting has received the greatest attention. Inability to remember, according to trace theory, means that the present problems cannot come into communication with an older trace or trace system. This may be due to three causes. First, the trace may have disappeared. Such an occurrence may be due to a lapse of time, through lack of cohesion in the parts of the structure, or through interaction with other traces or new processes. Second, the trace may not be able to exert an influence on the present occasion, that is, it may be unavailable. Third, there are instances

in which the present condition cannot communicate with the trace. These three causes are not to be considered mutually exclusive, but in each case of forgetting, all may play some part.

Bartlett, as reported by Cronbach (1954), extended this view of forgetting and retention. He suggested that memory cannot be explained solely through the effects of a passage of time upon learning. It is a reconstruction process operating in such a way that when an individual encounters a situation, he attempts to make it as sensible as possible. On the recurrence of the situation it is thought that, rather than filling in the gap left through the passage of time, the individual makes a new organized interpretation of the whole thing. This new interpretation is as regular and consistent as it can be made. To eliminate errors in recall, then, the structure and significance of a situation must be stressed during the original learning.

A different view of retention and forgetting is held by some psychologists, who have come to regard an active process of interference between the old and the new learnings as the main cause of forgetting. This process or interaction is called retroactive inhibition. In retroactive inhibition some other learning occurs between the learning and recall of the original material and interferes with its retention. Another similar situation, called proactive inhibition, occurs when the interfering material was learned prior to the learning and recall of something else.

Melton and Irwin (1940) distinguished between two kinds of proactive inhibition. One case involves the retardation of learning an activity because of prior experience, a phenomenon sometimes referred to as

negative transfer. The second case occurs when the retention of an activity is impaired by the influence of earlier activities.

It is also possible that repression plays a part in forgetting. In this process, unacceptable ideas pass from the conscious to the unconscious and are no longer recalled. While this may explain some forgetting, it is not generally felt to hold for all kinds.

An examination of research conducted in the area of retention may provide a meaningful elaboration of some of the above points of view.

In reviewing the literature on retroactive inhibition, Britt reported that "... it is well known that the degree of revival of a previously acquired activity depends on the kind and amount of activity which intervenes between the original learning of the activity and its reinstatement" (1935,p.381).

Two major influences on the amount of interference noted in his report were the similarity of the original and interpolated material and the degree of learning of the original material. It was found that as the degree of similarity increased, the degree of retroactive inhibition also increased to a maximum, then as the materials approached identity, the amount of retroactive inhibition decreased to zero with simple repetition. It was also noted that the greater the degree of learning of the original material, the less susceptible it was to retroactive inhibition.

Britt's first conclusion received subsequent verification in experiments by Johnson (1933) and Melton and von Lackum (1941). In these experiments, serial lists of nonsense syllables were used as subject matter.

On the other hand, Hall (1955), using meaningful material (the characteristics and customs of a hypothetical primitive tribe of people), found no relationship between the amount recalled and the degree of similarity between the interpolated and original material.

Again using meaningful school materials, Ausubel and his associates (1957) found that (a) proactive rather than retroactive inhibition was the determining cause of forgetting; (b) interpolated material, substantially similar to the original material, but not identical with it, does not result in retroactive inhibition, but is sometimes as valuable as repetition of the original material in improving recall. They feel that the extrapolation of the findings of experiments based on meaningless material to the classroom situation is a questionable procedure.

Using a variety of methods of learning addition facts with grade two pupils, Swenson (1949) was led to conclude that retroactive inhibition appeared more frequently and in greater amounts when a drill method was used than when the children were taught to organize the facts around generalizations.

The effect of a passage of time on the recall of learned material has received considerable attention in experiments. In an early study Bruene (1928) reported that over the summer vacation the greatest loss occurred in arithmetic computation, with losses also found in spelling, language usage, history and literature. There was little or no loss in arithmetic reasoning while reading, nature study and science showed increases. In reading, more of the bright children gained or remained the same over the summer vacation. In arithmetic, more of the average

children fell into this class.

Kolberg (1934) found that over the summer vacation there was an improvement in knowledge of subject matter, rather than a loss, if the material was easy. Contrary to Bruene's study, it was found that when the entire range of intelligence was considered, there was no relationship between retention and intelligence quotient. This is in keeping with the findings of Bassett (1929) who reported low positive correlations between retention and mental age.

In a study of junior high school pupils, Schrepel and Laslett (1936) confirmed the findings of Bruene, as far as reading and computation in arithmetic were concerned. In other areas no serious losses in subject matter were noted. They also found that the pupils of greater mental age, as a group, lost less or gained more knowledge over the summer vacation than did pupils of lesser mental age.

In considering further the relationship between intelligence and retention, Sister M. Lahey (1941) reported positive, but low correlations between intelligence test scores and fundamental operations in first year algebra. Correlations between intelligence and the retention of the ability to solve verbal problems were higher.

Grant (1932) found positive correlations between intelligence and retention, the coefficients being the highest for the most meaningful material.

In investigating the retention of course outcomes in educational psychology, McDougall (1958) found that the abilities to interpret and extrapolate material were retained to a significantly higher degree than the ability to recall knowledge or translate this

knowledge from one form to the other. One might observe that the difference appears to favor the more meaningful outcomes.

Tyler (1930) attempted to determine whether information that is seldom used would be more quickly forgotten than explanations that can be commonly applied to everyday life and methods of thinking that can be employed in practical situations. He gave three tests in science, one an information test, another an explanation test, and a third, a generalizations test. These were repeated after an eight-month interval. There was a distinct loss in the factual information test, but only slight differences in the other two, suggesting advantages in retention for more meaningful material.

Freud and Cheronis (1940) reported similar findings. The subject matter best retained in a physical science course appeared to be principles and theories, their applications and related facts. Material showing the poorest retention was memorized without the use of reason.

Johannsen and associates (1932) and Dietze and Jones (1931) suggest that scores on a memory test seem to be a function of the kind of material learned, the more familiar being retained best. The latter study also indicated that factual material (in this case, three stories) was forgotten less rapidly than either nonsense syllables or meaningful materials learned by rote.

An attempt was made by Craig (1956) to determine the effects of directing learners' discovery of established relationships upon retention and the ability to discover new relationships. He reported that the groups receiving the greater amount of direction learned more relationships, and in a delayed retention test after thirty-one

days, had retained more than the independent discovery groups. This would suggest that supplying information to the student to make the problem more meaningful resulted in improved learning and retention.

In investigating the learning and retention of concepts, Reed (1946) noted that a set to learn meanings as well as names yielded a higher degree of retention than a set to learn names only. Logically formed concepts were found to be better remembered than those illogically formed.

In his experiments on learning involving a memorizing group and an understanding group, Katona (1940) reported that the memorizing group tended to follow the main features of the Ebbinhaus curve. Learning by understanding, however, brought about different effects, the average performance several weeks after training being as good as performance immediately following training.

Katona suggests that "during the interval between testing, additional practice of a different kind may strengthen an integrated knowledge by enriching and widening its scope" (1940,p.163). An alternative explanation for the apparent absence of forgetting when material is learned by understanding is found, according to Katona, in the belief that recall in the form of reconstruction does not produce the Ebbinhaus type curve as frequently as does recall in the form of reproduction.

In summarizing the material presented on retention and forgetting, one may note that the exact nature of the processes involved are not definitely known. The effect of the similarity of original and interpolated learning materials has not been firmly established, nor

has the relationship between intelligence and retention. In general, support has been found for the contention that more meaningful materials, such as principles and applications, are better retained, and that methods of study that help to develop meanings for children also promote retention.

Summary

In this brief review of the theory and research in the areas of learning, transfer and retention, it is possible to observe the divergent views held by psychologists. One may note, too, that experiments and research in these fields do not always yield similar results. Throughout this pattern of disagreement, however, there runs a thread of agreement concerning the importance of meaning or understanding in learning. It has generally been found that the more meaningful the method of teaching and learning employed, and the more meaningful the material involved in learning, the greater the amount learned and retained, and the greater the degree of transfer of learning.

CHAPTER IV

THE PILOT STUDY

Introduction

In June, 1958, a preliminary investigation was carried out to test the hypothesis that there is a relationship between the cognitive activity of the learner and the amount learned and retained. As well as giving an indication of the nature of these relationships, the pilot study permitted an evaluation, in a practical setting, of the method of study proposed for the major experiment.

Three grade seven classrooms in two junior high schools of the Edmonton Separate School system were made available for this investigation. A total of eighty-six pupils took part in the training and testing program.

Procedure

In the pilot study three types of learning activity were used. These were: the study of material for facts; the study of material to determine the significant relationships within it; the study of material to determine the major generalizations that could be made from it. Each class was randomly assigned a type of learning activity to be followed throughout the study.

On the first day of the investigation a pre-test was administered to all classes. This consisted of a reading selection in science entitled "Winds", and a twenty-eight item multiple-choice test. The

test contained ten factual questions, ten questions involving relationships and eight questions involving generalizations. The students were allowed ten minutes to read the selection and fifteen minutes to complete the test.

The following four daily periods were used for training the classes in their particular method of study. A different body of subject matter was used each day, although on a given day the material was common to all classes. Each class read the assigned selection quickly, then studied it in detail and marked the important items. The activities of the pupils were controlled during this period by the suggestions and questions of the experimenter. Time was allowed the students to re-read the selection before they attempted a ten-item multiple-choice test designed to measure the outcomes appropriate to each group. The test for the Fact group, for example, contained only questions of fact.

On the sixth day of the study, the groups were given the post-test. This was comparable in structure to the pre-test, though not equated with it. The reading selection was again from science, this time entitled "Radiation". The multiple-choice test consisted of twenty-eight items with the same distribution of questions as before. Time limits were again ten minutes for reading and fifteen minutes for testing.

A second test was also administered in this period. This was a twenty-four item multiple-choice test containing eight items measuring each of the three learning outcomes, fact, relationship and generalization. The questions were based on subject matter studied by all

classes during the second training period and were used as a measure of retention. The students were allowed fifteen minutes to complete the test.

Analysis of the Results

Analysis of the data was carried out using analysis of variance and covariance techniques. In all instances of significantly different means, homogeneity of variance was verified with Bartlett's test. In cases where the variance was found to be heterogeneous, the data were re-analysed using the Cochran and Cox test if the groups were of different sizes and simple t-tests if the groups were the same size or if the means were correlated. In all instances significance was claimed if F or t reached the 5% level.

Pre-test

The results of the pre-test administered to all students on the first day of study are summarized in Table I.

TABLE I

PILOT STUDY
PRE-TEST RESULTS

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	29	17.93	5.88	5.83	1.91	6.97	2.58	5.10	1.89
Relationship	31	20.06	4.60	7.10	1.84	7.48	2.69	5.48	1.82
Generalization	26	20.42	4.70	7.15	1.58	7.73	1.99	5.54	1.82

Seven analyses of the data of Table I were carried out with analysis of variance techniques used in each instance. The following means were tested for significant differences:

1. Total scores in the three groups.
2. Fact subscores in the three groups.
3. Relationship subscores in the three groups.
4. Generalization subscores in the three groups.
5. Three subscores for the Fact group.
6. Three subscores for the Relationship group.
7. Three subscores for the Generalizations group.

The analysis of the pre-test scores revealed that there were no significant differences in the total test performance, nor in the subtest results within each of the three groups. In addition, there were no significant differences noted when the three groups were compared on the relationships and generalizations subsections of the test. Both the Relationship group and the Generalization group, however, were superior to the Fact group on the factual section of the pre-test. As a result of this difference, initial performance on the fact subsection was controlled through analysis of covariance in subsequent treatment of results.

Post-test

Post-test results are presented in Table II.

TABLE II

PILOT STUDY
POST-TEST RESULTS

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	29	12.72	4.85	4.97	1.89	4.17	1.75	3.59	1.42
Relationship	31	14.26	4.21	5.03	1.95	4.97	1.94	4.26	1.45
Generalization	26	16.69	4.96	6.23	1.79	5.96	2.28	4.50	1.71

The analysis of the post-test results followed the same pattern used with the pre-test. It was found that the Generalization group was superior to both the Fact and Relationship groups when mean total scores were compared. The same result was obtained when the mean scores on both the fact subsection and the relationship subsection were tested for significant differences. No method of study appeared to produce differences in performance on the generalization section of the test. When the subscores of each method group were analysed no significant differences were found. Training did not produce variation in results in the different learning outcomes, within any group.

Retention Test

Means and standard deviations for the three groups on the retention test are presented in Table III.

TABLE III

PILOT STUDY
RETENTION TEST RESULTS

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	30	18.20	4.29	6.93	1.36	5.90	1.85	5.37	1.75
Relationship	29	19.76	3.67	6.90	1.22	7.03	1.42	5.83	1.63
Generalization	27	18.00	5.08	6.48	1.90	5.96	2.26	5.56	1.48

On the retention test no significant differences were found when mean total scores were compared, nor when mean scores on the fact and generalization subsections were tested. Because the variance was heterogeneous, the Cochran and Cox technique was used to test mean differences on the relationship section of the retention test. This revealed that the Relationship group was superior in retention to both the Fact group and the Generalization group.

Bartlett's test revealed that the variance of the Fact group subscores was heterogeneous and since each subsection had the same N, an ordinary t-test was used to test the difference between means. It was found that scores on the factual section were significantly superior to those made on the relationship and generalization sections. The Fact group also retained significantly more relationships than generalizations. Analysis of variance showed that the Relationship group made superior scores on both the fact and the relationship sections

than it did on generalizations. The difference between means on the fact and relationship sections, however, was not significant. The mean fact subscore was found to be significantly greater than the mean generalization subscore in the Generalization group. The difference between the fact and the relationship score almost reached the .05 level of significance in this group. The generalization and relationship scores, however, were not found to differ significantly. The more meaningful methods of study appear to effect retention more uniformly than does the less meaningful method.

Item Analysis

Item analysis of the pre-test and the post-test was undertaken, following the experiment, to determine the mean difficulty indices for the tests and the subsections of each test. The method outlined by Davis (1949) was employed in this investigation. The mean index of difficulty for the pre-test was found to be 54.98, while that of the post-test was 42.10. The difference between these means was tested for significance and the resulting value of t was 3.34 which is highly significant. The post-test, then, was more difficult than the pre-test, a factor to be considered when interpreting the results of the earlier analysis. Within the subsections of the test, only in the area of relationships was there a significant difference between the pre- and post-test, and this again showed the post-test to be more difficult.

Summary of Findings

1. One of the major findings of the pilot study was that three

groups who began the period of investigation showing equal proficiency in learning important facts, relationships and generalizations, could be ranked in order of achievement after four days of instruction. The Generalization group was superior in performance to the Fact group and the Relationship group. Although there was a difference between the Fact and Relationship groups favoring the latter, this difference was not significant.

2. On factual questions there were significant differences on the pre-test favoring both the Relationship and Generalization groups over the Fact group. On the post-test the Generalization group was superior to both the Fact and the Relationship groups, while the latter pair on this occasion did not differ significantly.

3. In the area of relationships there were no significant differences on the pre-test, but on the post-test the Generalization group performed better than both the Relationship and the Fact groups.

4. There were no significant differences on either the pre-test or the post-test mean scores on the generalization sections.

5. From the above results it appears that the method of teaching for generalizations at the grade level and under the conditions described, leads to superior results in the learning of new material.

6. While differences between Fact and Relationship group scores did not reach significance, they consistently favored the relationship group.

7. Item analysis revealed that the post-test was significantly more difficult than the pre-test. This made comparisons of pre-test and post-test results of doubtful value. It is worthy of note, however,

that the Generalization group made a significantly higher score on the post-test, in spite of its greater difficulty.

8. In investigating retention it was found that there were no significant differences in total scores on a test of material learned one week earlier. In the subsections there were no differences in the areas of fact and generalization, but the Relationship group retained significantly more relationships than did the other two groups.

9. Within the subscores of each method group, significant differences in performance on the retention test were found. For the Fact group the order of degree of retention appeared to be facts greater than relationships greater than generalizations. The order for the Relationship group was: fact and relationships greater than generalizations. The Generalization group was found to recall factual material better than generalizations, and possibly better than relationships. The order for this group was: facts greater than relationships and generalizations.

Insights for Further Studies

1. A major difficulty encountered in the pilot study was the lack of equivalence of the pre- and post-tests. This seriously restricted the analysis of the data, since comparisons between pre-test and post-test could not be made. The investigator realized that before initiating a larger investigation, tests to be used should be equated in some manner.

2. The tests administered daily could be made a more integral part of the training period by having them corrected in class. At the

same time the experimenter could point out their appropriateness in terms of the desired learning outcomes and through this further emphasize the method to be employed by the group in study.

3. The retention test should be one that all groups have attempted on a previous occasion and should be comparable to the pre-test in difficulty and structure. This would allow pre-test performance to be controlled in the analysis of the retention test scores. The best method for securing this would seem to be to administer the post-test at appropriate intervals after the training period.

4. A control group should be included if the experiment is to extend over a long period of time. The control group would take the major tests, but would not have the training periods. In this way, allowance may be made in the analysis of the results for improvement brought about by experiences outside the experimental program.

5. Time limits imposed in the testing and training periods seemed adequate. It was found, however, that motivation, particularly in the case of the Fact group, appeared to diminish by the fourth training period. This, however, might be attributed to the time of the year in which the pilot study was undertaken and not be related to the experiment.

CHAPTER V

DESIGN OF THE EXPERIMENT

In this chapter the methods and materials employed in the experiment and the statistical procedures followed in the analysis of the data will be presented. The topics will be discussed in the following order: the subjects for the experiment, the tests and materials used, the procedure followed in the collection of the data, and the statistical methods used in the treatment of the results.

Subjects

The subjects for this experiment were the students in twelve grade seven classrooms in the city of Edmonton. Six classes were from five junior high schools in the Separate School system and six were from one large junior high school in the Public School system.

Before the experiment began, the twelve available classrooms were divided into four groups, three experimental and one control. Three of the public school classes were designated as the control group, and the remaining three functioned as one experimental group. The six separate school classes were divided randomly into two experimental groups.

The classes within each of the experimental groups were then randomly assigned the method of study they would employ during the experiment. These methods included the study of material for facts, the study of material for relationships and the study of material for generalizations.

The experimental groups and each class in the control group were to study material from two of the three subject matter areas, mathematics, science and social studies. The subject matter areas were assigned by chance, with the qualification that no class would study the same material during both stages of the investigation.

As a result of this division, there were three large groups formed on the basis of subject matter to be studied. These groups each contained three experimental classes and one control class. The division is summarized in Table IV, together with the number of pupils in each class.

TABLE IV

DISTRIBUTION OF SUBJECTS
BY METHOD AND MATERIAL TO BE STUDIED

	Social Studies and Mathematics	Science and Social Studies	Mathematics and Science
Fact Class	36	36	29
Relation Class	38	38	29
Generalization Class	26	39	34
Control Class	29	23	29

A total of three hundred and eighty-six students took part in the testing and training periods involved in the investigation.

Tests and Materials

Intelligence Test

The intelligence test selected for use in this investigation was the Otis Quick Scoring Mental Abilities Tests, Beta Test, Form Cm. This test was chosen because the Otis tests were not part of the

regular testing program for grade seven in any of the schools involved in the study. The test manual (Otis,1954) reports the average reliability coefficient for Form Cm of the Beta tests to be 0.86. This was found by determining the correlation between odd and even items on the test and correcting the result with the Spearman-Brown formula. Validity for the test is claimed by virtue of the fact that the items were selected from the Otis Higher Examination, an instrument previously found to have accepted validity.

Pre-Tests, Post-Tests, and Transfer Tests

The first problem faced by the experimenter involved the selection of adequate bodies of subject matter in mathematics, science and social studies, upon which the tests could be based. The basic criteria used to determine the suitability of the material were, first, it was to be at the level of understanding of the subjects, and second, it was to be related to some section of the grade seven course of studies that would not have been studied by the time of the experiment. Publishers' catalogues and book lists provided by the Department of Education provided a number of references meeting the first criterion. Consultation with superintendents and teachers provided guidance in meeting the second.

The subject matter used in constructing the first test in science consisted of a five page selection entitled "How Plants Live" (Limpus, Reid and Shore, 1951). This dealt mainly with the processes of respiration, photosynthesis and growth in plants. The second science test was based on a six page passage entitled "The Heat of the Body" (Meister, Keirsted and Shoemaker, 1948), in which warm and cold

blooded animals, natural protection against adverse climatic conditions, and familiar materials used in clothing were described. "What is Work" (Smith and Trafton, 1951), a four page discussion of the physical principles of work, provided material for the third test in science.

In social studies, the first body of subject matter to be used was a five page passage entitled "Democracy and Freedom" (Brown,1951). In this, democracies and dictatorships were compared and the means for preserving democratic forms of government were stressed. The second selection was "Local Government" (Goldring, 1948), a discussion of the development of local government in Canada and a description of the procedures followed in the election of a city council. The third social studies test was based on a six page passage entitled "The First People" (Dickie, 1950). This selection described the life of the early Indian in Canada emphasizing particularly his dependence upon his environment for food, clothing and shelter.

In developing three reading selections in mathematics reference was made to Henderson and Pringy (1956), Ruch, Knight and Studebaker (1942), Stein, Gilles, Hodgson and Deverell (1952), and Clark and Smith (1952). The first material dealt with varieties of angles and triangles, and presented a method for determining the area of a triangle. The second passage was entitled "Circles." In this, the parts of a circle were described, and methods outlined for calculating its circumference and area. The final reading selection in mathematics was on the topic of "The Formula." The development of formulae for the perimeter and area of squares and rectangles was presented and the advantages of the use of the formulae in mathematics was stressed.

Three preliminary tests in each of the subject matter areas, mathematics, science and social studies, were constructed. Each test consisted of thirty-six or more multiple-choice items, divided approximately equally between questions of facts, relationships and generalization.

All the preliminary tests were administered to 135 pupils in four grade seven rooms in the Edmonton Separate School system. The results of this testing program were subjected to item-analysis following the technique of Davis (1949). Using the upper and lower twenty-seven percent of the cases, difficulty indices were determined for each of the items on the tests.

From these data, items were selected for inclusion in the final tests on the basis of the following criteria: first, all tests within a subject matter area should have the same mean difficulty index; second, the subsections within a particular test should have the same mean difficulty index; third, within a subject matter area, the mean index of difficulty for a particular subsection should be the same on each of the three tests.

After items had been tentatively selected for the final test, analysis of variance technique was used to determine how well the above criteria had been met. Revisions were undertaken until analysis revealed no significant differences in mean difficulty indices. Mean difficulty indices for the tests are presented in Table V.

TABLE V

MEAN DIFFICULTY INDICES FOR SUBSECTIONS AND TOTAL TESTS

	Mathematics			Science			Social Studies		
	I	II	III	I	II	III	I	II	III
Fact	38.22	38.62	39.78	46.94	47.31	47.25	38.30	43.25	37.90
Relationship	29.25	38.38	37.97	44.97	45.19	35.78	35.34	42.28	40.31
Generalization	29.93	29.61	36.82	50.44	44.81	49.88	43.38	43.47	44.31
Total	32.58	35.79	38.25	47.45	45.77	44.30	39.01	43.00	40.85

In order that all types of questions on the final tests should receive a fair amount of the students' time during the examination period, it was decided that the questions should be arranged in a definite order. A fact question was first on all tests, followed by a relationship question, followed in turn by a generalization question. This pattern was repeated throughout each test. Within this framework, the questions selected on the basis of their difficulty indices were randomly assigned a position on the final test. The questions were numbered consecutively, with no indication that they were testing different learning outcomes.

Reliability coefficients for the final tests were calculated by the method of rational equivalence. A modification of the standard Kuder-Richardson formula provided by Walker and Lev (1953,p. 311) was used. The method of rational equivalence stresses the intercorrelation of the items within the test as a whole. It is a measure of the internal consistency of the test and as such "... yields a type of reliability estimate

analagous to those obtained by subdividing a test" (Thorndike,R.E., 1951). According to Walker and Lev (1953), the formula provides a kind of average of the various reliability coefficients which could be obtained from all the possible ways the test items could be subdivided for use with the split-halves method for calculating reliability. Table VI provides a summary of the reliability coefficients and the standard errors of measurement for the nine major tests used in the investigation.

TABLE VI

TEST RELIABILITY AND
STANDARD ERROR OF MEASUREMENT

	Mathematics			Science			Social Studies		
	I	II	III	I	II	III	I	II	III
r	.69	.74	.65	.51	.70	.76	.79	.51	.74
S.E. meas.	2.16	2.14	2.15	2.26	2.20	2.14	2.19	2.26	2.18

The low reliability coefficients indicate that there would likely be a substantial variation in the scores of individuals taking the tests. However, since the results were to be used for the evaluation of group, rather than individual performance, the effects of unreliability should be less pronounced.

As has been noted, the items for the tests used in this experiment were based on short bodies of subject matter presented to the testee for study during each testing period. These items were designed to measure the facts, relationships, and generalizations found in the reading selection, outcomes that were differentiated through careful definition. In addition, subject matter experts

were consulted during the construction of the tests. Since these procedures follow the suggested outline for securing content validity (American Psychological Association, 1954) it was felt that the tests had adequately met this requirement.

Samples of the reading materials and the tests are included in Appendix A.

Materials for the Training Periods

In each of the three subject matter areas, materials and tests were required for four training periods. The same criteria were applied as were used in the selection of the subject matter for the major tests, namely, first, the material should be at the level of understanding of the subjects, and second, it should be related to some part of the course of studies in mathematics, science and social studies that had not been covered at the time of the experiment. In the training periods the lengths of the reading selections were from one and one-half to two typewritten pages.

The topics covered in the instructional periods in science were "The Balance in Nature", in which natural plant-animal communities and factors that disrupt these relationships were discussed: "Wind", in which the cause of wind is presented as well as an account of the difference between local and prevailing winds; "The Effects of Heat", including an explanation of expansion and changes of state in terms of the molecular structure of matter; "Radiation" presents the properties of radiant heat, and practical applications in the form of the thermos bottle and the selection of appropriate clothing.

In social studies the material for the first training period was entitled "The Law that Made a Nation". This was a discussion of the British North America Act and the division of power between the federal and provincial governments. The second training period used a passage entitled "Canada Comes of Age", which described Canada's development as an independent nation in the Commonwealth. "Canada in the United Nations" was the topic for the third practice period. In this selection Canada's role as a middle power and her position as leader of the smaller nations was discussed. The final topic used in training in social studies was entitled "The Bush Pilots." Present-day bush fliers are compared with those of earlier periods in the history of Canadian aviation. The hardships of bush flying and its value to Canadian development were also stressed.

The first selection to be used in the mathematics classes was entitled "Decimals." In this the meaning of the decimal fraction was discussed and examples of addition, subtraction and multiplication of decimals presented. "Percentages" was the topic of the second practice period. In this the relationships between decimals, vulgar fractions and percentages were explained and examples given of the use of percentage in practical situations. In the third period "Arithmetic in Business" was the name given to the reading selection. Ideas of mark-up, reduction, net cost, profit and loss were presented with computational illustrations of the arithmetic processes involved in each of these. The topic for the final training period in mathematics was "Interest." Here the problems of borrowing money were discussed and the formula for simple interest developed and applied.

To accompany each of the topics in the three subject matter areas, short multiple-choice tests were constructed to be used as part of the training period. For each topic three tests of ten items were designed, one based on the facts of the selection, one on the relationships and one on the generalizations. Samples of these tests are included in Appendix (B).

Since each body of subject matter was to be employed in two different groups of classes, lesson plans were designed to establish some degree of uniformity in the presentation of the materials during the training periods. For each lesson three plans were required, one for the group studying the material for facts, one for the relationship group and one for the generalization group. As the method to be employed in the training period was to be the question and answer technique, the lesson plans consisted of a series of questions appropriate to each method group. For example, fact questions were of the variety:

(a) What is the name given to an animal that lives on another but does not eat it outright?

(b) When did the British North America Act become law?

Relationship questions included:

(a) In what way are the members of the House of Commons and the Senate different?

(b) What is the effect of radiant heat upon the empty spaces through which it travels on its way from the sun to the earth?

Questions based on generalizations included:

(a) Why have scientists come to expect breezes to blow from a lake to the land on a hot summer day?

(b) Why is the House of Commons considered to be the most important part of the machinery of the government?

Samples of lesson plans used in the experiment are included in Appendix C.

Procedure

Since each class was to study material from two subject matter fields, the experiment was divided into two stages, one for each subject involved. The procedures followed in each stage of the investigation were identical. Daily class periods of thirty-five minutes each were made available to the experimenter and these were found to be adequate for all but the delayed tests, where an additional fifteen minutes were required.

The first period of the investigation was devoted to the administration of the Otis Quick-Scoring Mental Abilities Test.

In the second period a preliminary test was administered. All classes in a subject matter group, that is, one control and three experimental classes, took the same test. Mimeographed copies of the reading selection were distributed to the class and the pupils were allowed twelve minutes to read the material. Those who finished early were encouraged to continue studying until the time had expired. Following this period, the pupils were given a multiple-choice examination based on the reading selection. Fifteen minutes were allowed for the completion of the test.

The items in the test measured the three learning outcomes: knowledge of facts, knowledge of relationships and knowledge of

generalizations. The results of this test were taken to indicate the group's ability to obtain the desired outcomes without training, a factor to be controlled in subsequent analysis.

The following four daily periods were utilized as training periods for the experimental classes. At the beginning of each period, a mimeographed selection, approximately one and one-half pages in length, was distributed to the class. The pupils were allowed three minutes to become familiar with the day's topic. The following fifteen minutes were devoted to a careful study of the material. The activities of the class during this time were determined by the outcomes to be sought, one class studying the facts in the selection, another the relationships and the third, the generalizations. The suggestions and questions of the experimenter directed the pupils' activity during this period and they were encouraged to mark important facts, relationships or generalizations as they were developed during the study period. In the study of facts, for example, the pupils concentrated on identifying and marking the significant facts in the selection. No consideration was given to the relationships that existed between these facts, nor to generalizations that could be made from them.

The same material was used by each class in a particular subject matter field and the same time limits and general procedures were followed.

At the end of the fifteen minute period the pupils were allowed three minutes to re-read the selection to note the important items marked earlier.

After re-reading the material, a ten-item multiple-choice test

was administered to each class, eight minutes being allowed for its completion. Each test was designed to cover the outcomes appropriate to a particular class. For example, the test for the fact class dealt only with the facts studied, no mention being made of relationships or generalizations. Similar restrictions were imposed upon the items of the tests for the relationship and generalization classes.

The tests were corrected by the students with answers provided by the experimenter. As this was done, stress was placed on the relationship between the acceptable answers and the outcomes sought. For example, in the relationship class, the kind of relationship involved in the answer was mentioned. Through this procedure it was felt that the testing period would emphasize further the particular activity of the class. The final five minutes of the training period were spent in this manner.

During the sixth period, a post-test was administered. This was similar in structure to the pre-test and equated with it in degree of difficulty. The pupils again were allowed twelve minutes to read the material and fifteen minutes to complete the test. In this test, also, all learning outcomes, facts, relationships, and generalizations were examined. All classes, including the control class, in a particular subject matter field were given the same test.

Three weeks after the administration of the post-test, a third test, similar in design and equated with the pre-tests and post-tests in degree of difficulty, was administered. The same time limits were in force as in previous testing situations. The purpose of this test was to determine the degree to which the effects of training in a

particular method would be transferred to a new situation after an interval in which there was no training in that subject. During the same period the post-test was repeated in all classes, as a delayed retention test. On this occasion, the reading selection was not included in the test. The pupils were again allowed fifteen minutes to attempt the items.

The eight periods described, namely, the administration of the intelligence test, the pre-test, the four training periods, the post-test, the transfer and retention tests, constitute one stage of the experiment. These periods are summarized for one subject matter group in Table VII.

In the interval between the first post-test and the first transfer test, the second stage of the study was undertaken. This involved a change in subject matter for each class and a repetition of the procedures outlined above, except that the intelligence test was not administered a second time. Each class continued to use the method of study assigned to it at the beginning of the experiment. In addition, the order of materials used for pre-tests and post-tests was reversed in the second stage of the experiment.

For the experimental classes the complete investigation required a total of thirteen class periods of thirty-five minutes and two periods of forty-five minutes, the latter for the administration of the transfer and retention tests. The control groups did not take part in the training periods and consequently were involved in five thirty-five minute and two forty-five minute periods.

TABLE VII

TESTING AND TRAINING PROGRAM FOR ONE SUBJECT MATTER GROUP

	Seven Consecutive School Days				Three Weeks Later	
	Day I	Day II	Days III-VI	Day VII	Day VIII	
Fact Class	Otis IQ Test	Reading Selection RA Pre-Test T-1	Practice on Facts 4 Training Periods 4 Informal Tests	Reading Selection RB Post-Test T-2	Reading Selection RC Transfer Test T-3	Retention Test (Repeat T-2)
Relationship Class	Otis IQ Test	Reading Selection RA Pre-Test T-1	Practice on Relationships 4 Training Periods 4 Informal Tests	Reading Selection RB Post-Test T-2	Reading Selection RC Transfer Test T-3	Retention Test (Repeat T-2)
Generalization Class	Otis IQ Test	Reading Selection RA Pre-Test T-1	Practice on Generalizations 4 Training Periods 4 Informal Tests	Reading Selection RB Post-Test T-2	Reading Selection RC Transfer Test T-3	Retention Test (Repeat T-2)
Control Class	Otis IQ Test	Reading Selection RA Pre-Test T-1		Reading Selection RB Post-Test T-2	Reading Selection RC Transfer Test T-3	Retention Test (Repeat T-2)

Statistical Analysis

The major techniques utilized in the treatment of the results of this experiment were the analysis of variance and covariance.

Since it was not possible to match the groups involved in the investigation prior to the beginning of the experiment, it was decided to equate the groups statistically on certain variables. Mental age was one factor considered to be worth controlling as it would, in effect, equate the pupils in their level of ability. In addition, since the classes used in the experiment were from different schools, pupils would likely have somewhat different backgrounds of experience in the methods of study employed in this investigation. By making allowance for this through the control of pre-test scores by the covariance technique, it was felt that a truer picture of change brought about by training would be achieved.

The effective use of analysis of variance and covariance require that a number of basic assumptions be met. McNemar (1955) gives two assumptions for the analysis of variance, first, that the cases constituting each group have been drawn from a normally distributed population of scores for the trait, and second, that the groups have the same variance. Lindquist (1953) adds to this list the assumption that all treatment groups were originally drawn at random from the same parent population. Siegel (1956) suggests, too, that the variables must have been measured in at least an interval scale. Johnson (1949) agrees with McNemar and Lindquist, but indicates that the assumption of the normal distribution of the population is not particularly important. There is doubt expressed in some areas, too, concerning the degree to

which other assumptions must be met in the use of analysis of variance. Maxwell, for example, states:

> In practice we seldom, if ever, know the exact extent to which these assumptions are justified by our data. But, fortunately, the t-test, and the F-ratio test for comparing a number of means, are, what recently have been christened, 'robust' tests -- they are
> (i) remarkably insensitive to non-normality in the parent populations, and
> (ii) in the commonly occurring case where the samples are of equal size the tests are not sensitive to inequalities of variance among the populations sampled (1958,p.36).

Wert, Neidt and Ahman note that "it is becoming more apparent that the analysis of variance technique is sufficiently satisfactory even when there is considerable departure from the strict fulfillment of the assumptions" (1954,p.184). Lindquist elaborates this somewhat by observing that "unless the heterogeneity of either form or variance is so extreme as to be readily apparent upon inspection of the data, the effect upon the F-distribution will probably be negligible" (1953, p.86).

Concerning the effects of non-normality of data, Cochran reports:

> ...no serious error is introduced by non-normality in the significance levels of the F-test or of the two-tailed t-test. While it is difficult to generalize about the range of populations that were investigated, this appears to cover most cases encountered in practice. If a guess may be made about the limits of error, the true probability corresponding to the tabular 5 percent significance level may be between 4 and 7 percent. For the 1 percent level, the limits might be taken as $\frac{1}{2}$ percent and 2 percent. As a rule, the tabular probability is an underestimate: that is, by using the ordinary F and t tables we tend to err in the direction of announcing too many significant results (1947,p.24).

Although it appears that rigorous testing of the assumptions underlying analysis of variance is not mandatory, they were validated statistically in this investigation when this was possible.

Meeting the assumption of random sampling was a source of difficulty in this study. Certain factors prevented the experimenter

from selecting schools strictly at random from the population. Size of classes, accessibility, and lack of interest on the part of the teachers were factors that required consideration and eliminated some schools from the study. In addition, certain other schools, through internal difficulties, were not available for experimentation. As a result of this, the means obtained for any given treatment must be regarded as biased estimates of the corresponding means for the real population.

Considering the problem of the assumption of random sampling and its effect on the results of educational experiments, Lindquist states:

> Fortunately, however, in most experiments we are not so much interested in estimating the population means for a given treatment, as in estimating the rank order of the treatments on the basis of their effectiveness for the whole (real population). For this purpose, it does not matter if all obtained treatment means are biased, so long as all are equally biased in the same direction. ...All the treatments may do better with the accessible schools than they would with the non-accessible schools, but there may be no reason to suppose that any one treatment will do relatively better than any other for either group of schools (Lindquist, 1953, p. 180).

Inasmuch as there did not appear to be any differences between selected and unselected schools that would affect responses to one treatment more than others, it was felt that the failure to meet the assumption of random sampling would not seriously affect the results of the experiment.

The assumption of normality could not be tested statistically because of the small number of pupils in each class. In discussing the use of chi-square in testing the goodness of fit of a normal curve to an actual distribution, Garrett (1953) suggests that there should be no experimental frequencies less than five. Since the largest treatment group contained only twenty-nine cases, this

criterion could not be met. As an approximate test of normality, the cumulative percentage distribution of the most markedly skewed samples were plotted against obtained scores using normal probability paper. When the cumulative percentages thus plotted fall on a straight line the distribution is considered normal (Edwards,1950).

Homogeneity of variance was tested using the method developed by Hartley (1950) in which the ratio between the largest and smallest variance is computed. Tables are available (Walker and Lev,1953) for determining the upper five percent and one percent points for this ratio, called F_{max} by Hartley, in a set of $\underline{k}$ mean squares all based on $\underline{n}$ degrees of freedom. As this method is a simplified test for homogeneity of variance, doubtful cases were subjected to Bartlett's test as outlined in Edwards (1950).

The assumptions underlying the analysis of covariance are essentially those for analysis of variance, to which Lindquist (1953) adds (a) the criterion measures are unaffected by the treatments, (b) the regression of the criterion variable on the variable on which comparisons are to be made is the same for all treatment populations (c) this regression is linear.

The first of the assumptions was readily met, since both measures serving as criterion scores, namely the intelligence test and the pretest, were administered before treatments began. Walker and Lev (1953) provided a test for homogeneity of regression in which the sum of squares for differences among group regression lines and the sum of squares of deviations of individual scores from the separate regression estimates are obtained, having $k-1$ and $N-2k$ degrees of freedom, where

N equals the number of cases and k equals the number of treatments. The ratio of the two mean squares is distributed as F and this was used to test the hypothesis that there was no difference among group regressions.

Maxwell (1958) provided a test of the significance of linear regression based on analysis of variance that was used to validate the third assumption for covariance.

Wherever basic assumptions could be met, analysis of variance and covariance was utilized to determine the significance of mean differences found in the testing program. From each test administered, there were four scores available for each class: a fact subscore; a relationship subscore; a generalization subscore and a total score. Each test was taken by the four classes in one subject matter group, three experimental classes and one control. From these results, the following means were tested for significant differences.

1. Total scores in the four classes.
2. Fact subscores in the four classes.
3. Relationship subscores in the four classes.
4. Generalization subscores in the four classes.
5. Three subscores of the Fact class.
6. Three subscores of the Relationship class.
7. Three subscores of the Generalization class.
8. Three subscores of the Control class.

In instances where the variance proved to be heterogeneous, and the number of cases differed in the groups in question, the method of testing mean differences outlined by Cochran and Cox (1957) was employed. When

the number of cases in each group was equal, ordinary t-tests were employed.

In cases where assumptions concerning the use of analysis of covariance could not be met, means were tested through the application of analysis of variance.

Summary

The twelve classrooms taking part in the experiment were divided into three subject matter groups, each composed of three experimental classes and one control. Each experimental class was assigned a particular method of study to be followed throughout the investigation. The methods included the study of material for facts, the study of material for relationships, and the study of material for generalizations. Four thirty-five minute periods of training were given to each experimental class in two of the three subject matter areas: mathematics, science, and social studies.

Selected bodies of subject matter, suitable to the level of the pupils involved and related to the grade seven course of studies, served as learning materials for the testing program. Three multiple-choice tests, similar in structure and equated in degree of difficulty, were designed to accompany the learning materials and serve as pre-tests, post-tests and transfer tests. In addition, the Otis Quick-Scoring Test of Mental Abilities, Beta Test was given to each of the classes. Retention after a three-week interval was measured by a second administration of the post-test in each group.

Since it was not possible to match the groups prior to the

beginning of the experiment, they were equated statistically on the basis of mental ability and experience with the methods of study employed in the investigation. To do this, analysis of covariance was used with mental age and pre-test scores held constant. Where equating was not necessary, analysis of variance was employed. In all cases, the assumptions underlying the use of these techniques were first tested. In instances where these assumptions could not be met, recourse was made to simpler devices for the evaluation of mean differences.

CHAPTER VI

ANALYSIS OF MENTAL AGE AND PRE-TEST RESULTS IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE ONE

In this chapter two major analyses will be presented. First, mental ages will be examined to determine the existence of significant differences in class means. Second, mean total scores and subscores in the pre-tests of the three subject matter areas, mathematics, science and social studies, will be compared to test the hypothesis that the classes within a subject matter group do not differ in performance on the pre-test.

The purpose in investigating these mean differences is that mental age and pre-test scores will serve as criteria or predictor variables in subsequent analyses. Where differences exist, these variables will be controlled by the use of analysis of covariance. This procedure, in effect, will equate the classes within a subject matter group in mental ability and in the ability to determine the important facts, relationships and generalizations in a reading selection, prior to training.

Mental Age

A summary of mean mental ages for the classes, together with the corresponding standard deviations is presented in Table VIII.

TABLE VIII

STANDARD DEVIATIONS AND MEAN MENTAL AGES IN MONTHS FOR EXPERIMENTAL AND CONTROL CLASSES, STAGE ONE

	n	Mean	Standard Deviation
Social Studies - Mathematics Group:			
Fact Class	29	157.66	21.99
Relationship Class	22	168.55	21.42
Generalization Class	19	169.74	19.82
Control Class	23	161.26	23.23
Science - Social Studies Group:			
Fact Class	26	156.00	17.78
Relationship Class	24	154.54	16.78
Generalization Class	28	166.57	14.79
Control Class	16	154.13	12.42
Mathematics - Science Group:			
Fact Class	22	163.00	13.85
Relationship Class	23	152.74	16.39
Generalization Class	27	167.56	17.07
Control Class	23	158.87	18.01

Homogeneity of variance of the entire group of classes was tested by the Hartley method and found to be satisfactory. Mean mental ages were then compared using analysis of variance. The results of this investigation are summarized in Table IX.

TABLE IX

ANALYSIS OF VARIANCE OF THE MENTAL AGES FOR ALL CLASSES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	11	6,000.51	546.14	
Within Groups	270	80,390.49	297.74	1.83*
Total	281	86,398.00		

* significant at .05 level

The F-ratio obtained in this analysis reached the .05 level of significance, indicating that the classes differed in mean mental age. To determine the extent to which this difference would have to be controlled, the classes were divided into the three subject matter groups and the mental ages of the four classes in each group were analyzed. Table X contains the results for the Social Studies - Mathematics group.

TABLE X

ANALYSIS OF VARIANCE OF THE MENTAL AGES OF THE SOCIAL STUDIES-MATHEMATICS GROUP, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	2,404.35	801.45	
Within Groups	89	42,126.12	473.33	1.693
Total	92	44,530.47		

The F-ratio in this instance did not reach the .05 level of significance. These classes did not differ in mean mental age and consequently it was not necessary to control this factor in succeeding treatments of the data obtained from the Social Studies - Mathematics group.

The results of the analysis of variance for the Mathematics - Science group are given in Table XI. In this case differences were found to be significant beyond the .05 level. The same result was obtained from the analysis of the mean mental ages for the Science - Social Studies group which is summarized in Table XII. The classes

TABLE XI

ANALYSIS OF VARIANCE OF THE MENTAL AGES
OF THE MATHEMATICS-SCIENCE GROUP,
STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	2,918.79	972.93	
Within Groups	91	24,655.80	270.94	3.59*
Total	94	27,574.59		

* significant at .05 level

TABLE XII

ANALYSIS OF VARIANCE OF THE MENTAL AGES
OF THE SCIENCE-SOCIAL STUDIES GROUP,
STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	2,668.76	889.59	
Within Groups	90	22,608.57	251.21	3.54*
Total	93	25,277.33		

* significant at .05 level

in each of these groups do not have the same mean mental age, indicating that analysis of covariance should be used to control the effects of these differences in subsequent investigations.

Pre-Tests in Mathematics, Science and Social Studies

In this investigation each subject matter group was composed of four classes, three experimental and one control. The pre-test administered to each class yielded a score for three learning outcomes, facts, relationships and generalizations, and a total score. The analysis of the pre-test consisted in comparing the mean scores made by the four classes in one subject matter group, plus an examination of the subscores within each class. The results of the analysis of pre-test performance for the subject matter groups will be presented in the order: mathematics, science, social studies.

Mathematics

Means and standard deviations for the four classes taking the pre-test in mathematics are presented in Table XIII.

TABLE XIII

MEANS AND STANDARD DEVIATIONS FOR THE PRE-TEST IN MATHEMATICS, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	22	10.59	2.97	4.00	0.976	4.26	1.35	2.32	1.04
Relationship	23	9.96	3.17	3.70	1.66	3.74	1.63	2.52	0.85
Generalization	27	13.63	4.99	5.00	1.80	5.04	1.76	3.59	1.82
Control	23	11.09	3.69	3.91	1.68	3.91	2.02	3.26	1.05

The application of Hartley's test to the total scores revealed that the variance was heterogeneous, indicating that analysis of variance could not be undertaken with the complete group. After omitting the Generalization group from consideration, the variance of the remaining groups was found to be homogeneous. In addition, when the Generalization group was not considered, the remaining classes did not differ in mental age, consequently mean total scores were compared using simple analysis of variance. The results are summarized in Table XIV. In this instance the F-ratio is not significant, which indicates that the three classes, Fact, Relationship and Control, performed equally well on the pre-test in mathematics, as far as could be determined from the total scores.

TABLE XIV

ANALYSIS OF VARIANCE OF THE TOTAL SCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE[a]

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	2	14.76	7.38	
Within Groups	65	706.11	10.86	0.680
Total	67	720.87		

[a]Generalizations group not included.

The Cochran and Cox technique was employed in comparing the mean total score of the Generalization group with that of the other classes taking the Mathematics test. The results of this analysis are presented in Table XV.

TABLE XV

MEAN DIFFERENCE TESTS FOR THE TOTAL SCORES OF THE GENERALIZATION GROUP ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

	t'_{05}	t'_{01}	t
Generalization and Fact	2.064	2.795	2.578
Generalization and Relationship	2.062	2.792	3.084
Generalization and Control	2.063	2.795	2.022

The generalization group was superior in pre-test performance to both the Fact and the Relationship groups. Because of these differences, it was decided that pre-test total scores should be controlled in the later analyses of the performance of this subject matter group.

When the distribution of scores made by the classes on the fact subsection of the test was examined, it was found that the variance was heterogeneous. On this occasion the elimination of the Fact group from consideration produced homogeneity of variance among the remaining classes. The classes still differed in mean mental ages and consequently, after verifying that regression was linear and coefficients were homogeneous, pre-test scores were compared using analysis of covariance. The results of this analysis are given in Table XVI. The resulting F-ratio was not significant at the .05 level. The Relationship, Generalization and Control groups did not differ in performance on

TABLE XVI

ANALYSIS OF COVARIANCE OF THE FACT GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE[a]

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	2	6.70	3.35	
Within Groups	69	166.80	2.42	1.39
Total	71	173.50		

[a]Fact group not included.

the fact section of the pre-test.

The Cochran and Cox technique was employed to test mean differences between the Fact group and the other classes taking the Mathematics test. Table XVII summarizes the results of this test.

TABLE XVII

MEAN DIFFERENCE TESTS FOR THE FACT SUBSCORES OF THE FACT GROUP ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

	t'_{05}	t'_{01}	t'
Fact and Relationship	2.076	2.818	0.738
Fact and Generalization	2.065	2.793	2.423
Fact and Control	2.075	2.821	0.216

The Generalization group was superior to the Fact group in the fact section of this test. This difference necessitates the control of the pre-test scores in this area in subsequent analyses.

Homogeneity of variance and regression coefficients and linearity of regression were confirmed for the distribution of scores in the

relationship subsection of the test. Analysis of covariance was then undertaken, controlling mental age. The classes did not differ beyond the bounds of chance in their performance on this part of the pre-test, making it unnecessary to consider pre-test results in succeeding investigations. A summary of this analysis is presented in Table XVIII.

TABLE XVIII

ANALYSIS OF COVARIANCE OF THE RELATIONSHIP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	4.83	1.61	
Within Groups	90	192.36	2.14	0.75
Total	93	187.19		

To achieve homogeneity of variance in the generalization scores, the Generalization group was not included in the analysis. The remaining classes did not differ in mental age and as a result, simple analysis of variance was employed to investigate mean differences. In this instance, as summarized in Table XIX, the F-ratio was significant beyond the .01 level. The Control group was superior to both the Fact

TABLE XIX

ANALYSIS OF VARIANCE OF THE GENERALIZATION SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE[a]

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	2	11.22	5.61	
Within Groups	65	62.90	0.97	5.80*
Total	67	74.12		

[a] Generalization group not included.

*Significant beyond the .01 level.

group and the Relationship group in this section of the test. The results of the application of the Cochran and Cox technique to mean differences involving the Generalizations group are presented in Table XX. The Generalizations group made significantly higher scores than the Facts and Relationships groups on the generalization section of the pre-test. Because of these differences, the analysis of this section of subsequent tests requires the control of the pre-test results.

TABLE XX

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION SUBSCORES OF THE GENERALIZATION GROUP ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

	t'_{05}	t'_{01}	t'
Generalization and Fact	2.061	2.794	2.995
Generalization and Relationship	2.056	2.788	2.550
Generalization and Control	2.061	2.793	0.780

The subscores made by the Control group showed heterogeneity of variance when tested by the Hartley method. Because these means were correlated, differences were examined by the ordinary t-test for

TABLE XXI

MEAN DIFFERENCE TESTS FOR THE CONTROL GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

	Mean Difference	Standard Error	t
Fact and Relationship	0	-	-
Fact and Generalization	0.65	0.40	1.62
Relationship and Generalization	0.65	0.45	1.44

non-independent means. The Control group, as indicated in Table XXI, did equally well on the three subsections of the pre-test.

The variances of the distributions of scores made by the Fact group on the three subsections of the test were homogeneous, and as a result, analysis of variance was employed to test for significant mean differences. The members of the Fact group performed better on the fact and relationship sections than they did on the generalization sections. These differences indicate that pre-test results must be considered in later analysis of sub-test performance in the Fact group. The analysis is summarized in Table XXII.

TABLE XXII

ANALYSIS OF VARIANCE OF THE FACT GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	49.30	24.65	
Subjects	21	61.77	2.94	
Remainder	42	19.37	0.46	53.59
Total	65	130.44		

Heterogeneity of variance necessitated the use of the t-test for non-independent means in the analysis of sub-test performance in the Relationship group. The results are presented in Table XXIII. Both the fact and relationship score were significantly higher than the generalization scores in this class.

TABLE XXIII

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

	Mean Difference	Standard Error	t
Fact and Relationship	.04	.384	.104
Fact and Generalization	1.175	.330	3.561*
Relationship and Generalization	1.215	.327	3.716*

*Significant beyond the .01 level.

Later analyses of the Relationship group subscores will require covariance with the pre-test results controlled.

Analysis of variance was used to compare mean scores on the subsections of the pre-test for the Generalization group after homogeneity of variance had been confirmed. Table XXIV provides a summary of this analysis.

TABLE XXIV

ANALYSIS OF VARIANCE OF THE GENERALIZATION GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	36.43	18.22	
Subjects	26	216.10	8.31	
Remainder	52	35.57	0.68	26.78
Total	80	288.10		

The F-ratio was significant beyond the .01 level, scores on the fact and relationship sections again being higher than the generalization

score. As in previous instances, these differences indicate that pre-test scores must be controlled in subsequent analyses of subscores with the Generalization class in this group.

Science

Science pre-test means and standard deviations are included in Table XXV.

TABLE XXV

MEANS AND STANDARD DEVIATIONS FOR THE
PRE-TEST IN SCIENCE, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	26	11.30	2.77	3.46	1.42	3.73	1.66	4.12	1.26
Relationship	24	12.95	2.12	3.85	1.40	3.83	1.20	5.92	1.12
Generalization	28	13.46	3.51	3.78	1.62	4.39	1.51	5.28	1.56
Control	16	13.61	3.18	4.12	1.59	4.82	1.52	4.68	1.54

To secure homogeneity of variance, the Generalization group was not considered in the first analysis. Elimination of this group also produced homogeneity of mental ages among the remaining classes and as a result simple analysis of variance was used to compare mean total scores. Table XXVI contains a summary of this investigation.

TABLE XXVI

ANALYSIS OF VARIANCE OF THE TOTAL SCORES
ON THE PRE-TEST IN SCIENCE, STAGE ONE[a]

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	2	61.97	30.99	
Within Groups	63	446.47	7.09	4.372*
Total	65	508.44		

[a] Generalization group not included.

*Significant at .05 level.

Both the Control and the Relationship groups were superior to the Fact group in total test performance. The use of the Cochran and Cox technique showed that this difference was maintained in the case of the Generalization group. The comparisons made with the latter group are presented in Table XXVII. These differences necessitate the control of total scores in subsequent analysis involving these classes.

TABLE XXVII

MEAN DIFFERENCE TESTS FOR THE TOTAL SCORES OF THE GENERALIZATION GROUP ON THE PRE-TEST IN SCIENCE, STAGE ONE

	t'_{05}	t'_{01}	t
Generalization and Fact	2.055	2.777	2.476
Generalization and Relationship	2.057	2.781	.636
Generalization and Control	2.099	2.875	.138

Since regression was found to be non-linear, recourse was made to analysis of variance to determine mean differences in fact subscores in the science pre-test. As is indicated in Table XXVIII, the four classes did not differ in mean scores in this area of the test. Fact

TABLE XXVIII

ANALYSIS OF VARIANCE OF THE FACT SUBSCORES ON THE PRE-TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	4.59	1.53	
Within Groups	90	204.26	2.27	.674
Total	93	208.85		

subscores, therefore, will not have to be controlled in later investigations.

Analysis of covariance was used in the investigation of mean differences in performance on the relationship section of the pre-test, linearity of regression and homogeneity of variance and regression coefficients being confirmed beforehand. There were no differences in performance on this test, indicating that controls of these scores would not be necessary in subsequent analysis. Summary of the analysis of relationship subscores is given in Table XXIX.

TABLE XXIX

ANALYSIS OF COVARIANCE OF THE RELATIONSHIP
SUBSCORES ON THE PRE-TEST IN
SCIENCE, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	14.44	4.81	
Within Groups	89	170.60	1.92	2.51
Total	92	185.04		

A similar analysis was carried out with the generalization subscores, after confirming the necessary assumptions for covariance. The results are presented in Table XXX. The F-ratio in this instance

TABLE XXX

ANALYSIS OF COVARIANCE OF THE GENERALIZATION
SUBSCORES ON THE PRE-TEST IN
SCIENCE, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	20.60	6.87	
Within Groups	89	153.47	1.72	3.98*
Total	92	174.04		

*Significant at the .05 level.

was significant at the .05 level. Both the Relationship and Generalization groups obtained higher scores than the Fact group on this section of the test. These differences indicate that the pre-test generalization scores must be controlled in later analyses of performance.

After confirming homogeneity of variance, two-way analysis of variance revealed no differences in performance in subsections of the test by students in the Fact group. The analysis is shown in Table XXXI. No consideration need be given to pre-test performance in subsequent analyses of Fact group sub-test scores.

TABLE XXXI

ANALYSIS OF VARIANCE OF THE FACT GROUP
SUBSCORES ON THE PRE-TEST IN
SCIENCE, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	5.62	2.81	
Subjects	25	63.85	2.55	
Remainder	50	95.38	1.91	1.47
Total	77	164.85		

The same analysis conducted with the subscores of the Relationship group indicated that pre-test results would have to be controlled in later investigations. As may be observed in Table XXXII, the F-ratio was significant beyond the .01 level. In this instance, the generalization score was superior to the fact and relationship scores.

TABLE XXXII

ANALYSIS OF VARIANCE OF THE RELATIONSHIP GROUP SUBSCORES ON THE PRE-TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	34.03	17.02	
Subjects	23	35.71	1.55	
Remainder	46	71.91	1.56	10.90
Total	71	141.65		

A similar result was found on the analysis of the subscores of the Generalization group. Differences in pre-test scores must be controlled in further analyses of this kind. Table XXXIII contains a summary of these results. As in the previous class, generalization scores were superior to both the fact and relationship scores.

TABLE XXXIII

ANALYSIS OF VARIANCE OF THE GENERALIZATION GROUP SUBSCORES ON THE PRE-TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	31.88	15.94	
Subjects	27	102.32	4.12	
Remainder	54	86.79	1.61	9.90
Total	83	220.99		

Analysis of variance revealed no differences in performance within the pre-test by members of the Control group. The results

are summarized in Table XXXIV. It will not be necessary to consider

TABLE XXXIV

ANALYSIS OF VARIANCE OF THE CONTROL GROUP SUBSCORES ON THE PRE-TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	4.30	2.15	
Subjects	15	50.60	3.38	
Remainder	30	56.90	1.90	1.13
Total	47	111.80		

pre-test results in later investigations of the performance of the Control group on the subsections of the test.

Social Studies

The results of the administration of the pre-test in Social Studies are presented in Table XXXV. Homogeneity of variance was confirmed for

TABLE XXXV

MEANS AND STANDARD DEVIATIONS FOR THE PRE-TEST IN SOCIAL STUDIES, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M.	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	29	10.08	3.79	3.31	1.71	3.76	1.97	3.76	1.80
Relationship	22	12.33	4.73	4.00	1.69	3.64	1.96	4.68	2.10
Generalization	19	10.90	4.27	3.79	1.51	3.21	2.25	3.89	1.59
Control	23	14.57	5.04	4.47	1.62	4.68	2.07	5.30	1.74

all distributions in this test and, as the classes did not differ in mental age, analysis of variance was used throughout the investigation to determine significant mean differences.

The results of the analysis of the total scores are presented in Table XXXVI. The F-ratio in this case was significant at the .01 level.

TABLE XXXVI

ANALYSIS OF VARIANCE OF THE TOTAL SCORES ON THE PRE-TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	283.63	94.54	
Within Groups	89	1724.07	19.37	4.88*
Total	92	2007.70		

*significant at the .01 level.

The Control group was superior to the Fact and the Generalization group on this pre-test. These differences necessitate the control of pre-test total scores in subsequent analyses in this study.

Differences in performance on the fact subsection of the test were found to be within the bounds of chance. The F-ratio, as noted in Table XXXVII, was not significant. No consideration need be given

TABLE XXXVII

ANALYSIS OF VARIANCE OF THE FACT SUBSCORES ON THE PRE-TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	18.07	6.02	
Within Groups	89	241.11	2.71	2.22
Total	92	259.18		

these results in later treatment of the data.

There appeared to be differences, however, in performance on the relationship subsection of this test. The summary of the analysis is given in Table XXXVIII. The F-ratio is barely significant at the .05 level. Subsequent t-tests revealed no pairs of means that differed significantly and as a result, control of pre-test scores will not be necessary in later analyses.

TABLE XXXVIII

ANALYSIS OF VARIANCE OF THE RELATIONSHIP
SUBSCORES IN THE PRE-TEST IN
SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	34.33	11.44	
Within Groups	89	374.99	4.21	2.72
Total	92	409.32		

There were differences in performance on the generalization section of the test that were confirmed by the t-test. The F-ratio reported in Table XXXIX is significant beyond the .01 level. The Control group obtained better scores than the Fact and the Generalization

TABLE XXXIX

ANALYSIS OF VARIANCE OF THE GENERALIZATION
SUBSCORES ON THE PRE-TEST IN
SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	54.02	18.01	
Within Groups	89	296.26	3.33	5.41
Total	92	350.28		

groups, and the Relationship group was also superior to the Fact group in performance. Pre-test scores, therefore, must be controlled in analyses of the generalization sub-sections of later tests.

The analysis summarized in Table XL shows that the Fact group did not differ in its performance on the three learning outcomes measured in the pre-test. These scores, then, need not be controlled when later tests are analyzed.

TABLE XL

ANALYSIS OF VARIANCE OF THE FACT GROUP
SUBSCORES ON THE PRE-TEST IN
SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	.09	.046	
Subjects	28	8.34	.298	
Remainder	56	273.52	4.884	.009
Total	86	281.95		

The Relationship group showed variation in sub-test performance as revealed by the analysis presented in Table XLI. The class made a

TABLE XLI

ANALYSIS OF VARIANCE OF THE RELATIONSHIP
GROUP SUBSCORES ON THE PRE-TEST IN
SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	12.39	6.20	
Subjects	21	156.26	7.44	
Remainder	42	77.61	1.85	3.35
Total	65	242.26		

significantly higher score in the generalization section of the test than on the relationship section. The effects of these differences will therefore be controlled by analyses of covariance during the treatment of later test results.

The Generalization group followed the pattern of the Fact group in that no differences in performance were noted. As in the earlier case, control of pre-test scores will not be necessary. The analysis is summarized in Table XLII.

TABLE XLII

ANALYSIS OF VARIANCE OF THE GENERALIZATION GROUP SUBSCORES ON THE PRE-TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	5.16	2.58	
Subjects	18	109.26	6.07	
Remainder	36	68.84	1.91	1.35
Total	56	183.26		

On the pre-test, members of the Control group did significantly better on generalization than on either the fact or relationship sections. These differences, then, must be considered in later analyses involving comparisons of the performance of the Control group on the subsections of the tests. The analysis is summarized in Table XLIII.

TABLE XLIII

ANALYSIS OF VARIANCE OF THE CONTROL GROUP
SUBSCORES ON THE PRE-TEST IN
SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	8.03	4.02	
Subjects	22	185.88	8.45	
Remainder	44	32.64	.74	5.41
Total	68	226.55		

Summary

The analyses presented in this chapter revealed differences between classes in mental age and in familiarity with the methods employed in this investigation. Consideration must be given these differences, through the analysis of covariance, if subsequent test results are to be interpreted adequately.

Mental ages for both the Mathematics-Science group and the Science-Social Studies group were found to differ significantly and must be controlled.

Sections of each subject matter area to be held constant by analysis of covariance are as follows:

Mathematics: total scores, fact subscores, generalization subscores, Fact group subscores, Relationship group subscores, and Generalization group subscores.

Science: total scores, generalization subscores, Relationship group subscores, and Generalization group subscores.

Social Studies: total scores, generalization subscores, Relationship group subscores, and Control group subscores.

CHAPTER VII

ANALYSIS OF GAINS FROM PRE-TEST TO POST-TEST IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE ONE

After the experimental classes had completed training periods in one of the three methods of study, a post-test was administered to all classes. Pre-test scores were subtracted from post-test scores to obtain a distribution of gains made during the period of training. Analysis of these distributions was undertaken to determine the differential effects of training on the learning of facts, relationships and generalizations. Results will be presented for each subject matter group in the order; mathematics, science and social studies.

Mathematics

The means and standard deviations for the distribution of gains in mathematics are presented in Table XLIV. A negative mean indicates that the group, as a whole, made lower scores on the post-test than on the

TABLE XLIV

MEANS AND STANDARD DEVIATIONS FOR THE DISTRIBUTION OF GAINS FROM PRE-TEST TO POST-TEST IN MATHEMATICS, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	22	-0.91	3.53	0.18	1.94	-1.32	2.06	0.23	1.41
Relationship	23	-0.26	4.55	0.78	1.83	-1.04	2.64	0.00	1.45
Generalization	27	-1.96	4.47	0.26	1.53	-1.41	1.95	-0.82	2.49
Control	23	-1.74	3.24	-0.09	1.65	-1.13	2.12	-0.52	1.65

pre-test.

The assumptions concerning linearity of regression, homogeneity of regression coefficients and homogeneity of variance were confirmed for the total gain scores. Mean differences between the classes were then compared by analysis of covariance, with mental age and pre-test scores controlled. No significant differences were found between mean total gains for the four classes. Four training periods in a particular method of study did not produce an improvement in the performance of any of the classes, as measured by total gains from the pre-test to the post-test.

In the analysis of the fact subscores, it was found that covariance could not be used since the regression of mental age on gain was not linear, and the regression coefficients of the pre-test and gains distributions were not homogeneous. Since homogeneity of variance was confirmed for the fact subscores themselves, analysis of variance was used to compare means. As with the total gain distribution, no significant differences were found.[1] The training periods failed to produce differential performance on the post-test in mathematics.

Since differences in pre-test performance on the relationship section of the mathematics test were due to differences in mental age, pre-test scores were not controlled in the analysis of gains. The mean

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[1] Analysis of covariance was undertaken, holding mental age constant, in spite of the failure to meet the assumptions. It was felt that this procedure would reveal, at least in part, the influence of mental age on gain. As in analysis of variance, there were no significant differences.

gains in this section of the test were compared by analysis of covariance, with mental age held constant. There were no significant differences between the classes in the learning of relationships in mathematics.

To secure homogeneity of variance in the generalization section of the distribution the Generalization group was omitted. This also produced homogeneity of mental age and as a result, analysis of covariance with only pre-test performance constant was used to compare the means of the remaining three classes. As before, no significant differences were noted. The use of Cochran and Cox technique to compare means involving the Generalization group revealed the same pattern of non-significance. As in the other parts of the distribution, the training periods did not produce any differences in post-test performance.

Homogeneity of variance was confirmed in the subsections of the distributions for both the Control group and the Fact group. Two-way analysis of variance was used to compare mean differences in gains in each of these groups. No significant differences were obtained in the case of the Control group. The experiences of the Control group in the interval between tests did not produce any apparent effect on their ability to determine the facts, relationships and generalizations in a reading selection in mathematics. In the Fact group, however, gains in the fact and generalization sections were found to be superior to that made in the relationship section. Their higher performance on generalizations may be due in part to previous classroom practice in the application of mathematics to problem areas. The higher gain in the area of

facts could be explained on the basis of the training received in the experiment.

Since the variance was heterogeneous in the subscores of both the Relationship and Generalization groups, t-tests were used to investigate mean differences in these instances. The pattern of non-significant differences was maintained in this analysis as far as the Relationship group was concerned, training apparently producing no effect on post-test performance. In the Generalization group, fact scores were significantly higher than either relationships or generalizations. It seems that training in generalizations does not cause the student to ignore the facts in a selection, but quite to the contrary, produces an awareness of important facts.

Table XLV contains a summary of the F-ratios obtained from the analysis of gains from pre-test to post-test in mathematics. Since no significant differences were found between groups, it appears that the training periods were not capable of influencing the performance of pupils in this area.

TABLE XLV

F-RATIOS DERIVED FROM THE ANALYSIS OF
GAINS FROM PRE-TEST TO POST-TEST
IN MATHEMATICS, STAGE ONE

	F_{05}	F_{01}	F	Interpretation
Total	2.71	4.00	0.46	not significant
Fact scores	2.71	4.00	1.01	not significant
Relationship scores	2.71	4.00	0.01	not significant
Generalization scores[a]	3.14	4.95	0.26	not significant
Fact group scores	3.22	5.15	5.83	p less than .01
Relationship group scores[b]	-	-	-	-
Generalization group scores[b]	-	-	-	-
Control group scores	3.21	5.12	2.03	not significant

[a] Generalization group not included.

[b] Variance heterogeneous, t-test employed.

Science

The means and standard deviations for gains in science are summarized in Table XLVI.

TABLE XLVI

MEANS AND STANDARD DEVIATIONS FOR THE DISTRIBUTION OF GAINS FROM PRE-TEST TO POST-TEST IN SCIENCE, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	26	0.69	3.61	0.35	1.83	0.39	1.84	-0.04	1.51
Relationship	24	1.58	3.87	1.25	2.11	0.46	1.87	-0.13	2.23
Generalization	28	2.21	4.10	1.04	2.32	1.07	1.78	0.11	1.75
Control	16	-0.06	2.91	0.06	1.57	-0.06	1.44	-0.06	1.91

To compare mean and total gains in science, analysis of covariance was used with mental age and pre-test scores constant. No significant results were obtained from this analysis. It is interesting to note, however, that the trend of mean total gains runs from Control to Fact, to Relationship to Generalization in order of increasing values. This is also in the order of increasing amount of meaning associated with a method of study and may indicate that the training periods did have some effect on post-test performance.

The gains made by the four classes on the fact subsection of the distribution were investigated by analysis of covariance with mental age held constant. Again, no significant differences were obtained, nor was the trend in mean scores as clearly noticeable. The groups using the more meaningful methods, Relationship and Generalization,

again appeared to have higher mean scores, though, as noted differences were not significant.

In the relationship section, analysis of covariance with mental age controlled, revealed no significant differences in mean gain. The rank order of mean gains was the same as that observed with total scores, the groups being arranged in order of increasing meaningfulness of method.

Analysis of covariance with pre-test results held constant was used to compare means on the generalization section of the gains distribution. No significant differences were obtained from this investigation. The generalization section of the post-test appeared to be more difficult than the pre-test for the students, since lower scores were made by all classes except the Generalization class, who had received training in this area.

The analysis of the subscores within each group failed to reveal any significant differences. The training periods did not produce any marked effects on the performance of the students on the different subsections of the test.

The results of the analysis of the distribution of gains in science from the pre-test to the post-test were negative. No significant differences were found. The F-ratios obtained in the various investigations of mean differences are summarized in Table XLVII.

TABLE XLVII

F-RATIOS DERIVED FROM THE ANALYSIS OF GAINS FROM PRE-TEST TO POST-TEST IN SCIENCE, STAGE ONE

	F_{05}	F_{01}	F	Interpretation
Total	2.71	4.00	1.502	not significant
Fact subscores	2.71	4.00	1.411	not significant
Relationship subscores	2.71	4.00	0.498	not significant
Generalization subscores	2.71	4.00	1.258	not significant
Fact group subscores	3.18	5.06	0.612	not significant
Relationship group subscores	3.20	5.10	2.894	not significant
Generalization group subscores	3.17	5.01	1.730	not significant
Control group subscores	3.32	5.39	0.059	not significant

Unlike the results of the mathematics analysis, inspection of the distribution of gains in science showed a trend that appeared to favor the more meaningful methods of study. It would seem that the training periods influenced performance to a greater extent in science than in mathematics, although this could not be rigorously confirmed.

Social Studies

The means and standard deviations for the gains made by the classes in social studies are presented in Table XLVIII. In the

TABLE XLVIII

MEANS AND STANDARD DEVIATIONS FOR THE DISTRIBUTION OF GAINS FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	29	2.59	3.96	0.97	1.94	0.59	2.40	1.03	2.24
Relationship	22	2.68	4.18	0.73	1.84	1.55	1.65	0.41	1.94
Generalization	19	5.05	3.24	1.21	1.65	2.42	2.75	1.42	1.39
Control	23	-0 .39	3.19	-0.70	1.72	0.02	1.95	0.01	1.65

analysis of these results, mental ages were not considered since preliminary investigation revealed no significant differences between the classes in this group.

Mean total gains were examined using analysis of covariance, with pre-test scores in social studies held constant. The results of this analysis are summarized in Table XLIX. The F-ratio obtained in this instance was significant beyond the .01 level. A comparison of adjusted means was made and revealed that the Generalization group made significantly greater gains than both the Control group and the Fact group. The difference between the Generalization group and the Relationship group favored the former but did not reach the .05 level. The Relationship group gain was significantly greater than the Control group and in addition, the Relationship group was superior to the Fact group although the difference did not reach the .05 level of significance. The difference between the Fact group and the Control group was not significant, although the gain made by the former was greater. The mean difference tests are summarized in Table L.

TABLE XLIX

ANALYSIS OF COVARIANCE OF THE GAINS IN TOTAL SCORE FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	150.61	50.20	
Within Groups	88	753.86	8.57	5.86*
Total	91	904.47		

* significant beyond .01 level

TABLE L

MEAN DIFFERENCE TESTS FOR GAINS IN TOTAL SCORE FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

	Adjusted Mean Differences	t	Significance
Generalization and Fact[a]	2.89	3.34	$p < .01$
Generalization and Relationship	1.63	1.77	$.05 < p < .10$
Generalization and Control	3.54	3.75	$p < .01$
Relationship and Fact	1.263	1.51	$.1 < p < .2$
Relationship and Control	1.91	2.16	$.01 < p < .05$
Fact and Control	0.65	0.69	$.4 < p < .5$

[a] In each case difference favors group named first.

It would appear that in the field of social studies, the training periods experienced by the experimental groups influenced their post-test performance. The results of this analysis substantiate the hypothesis that the more meaningful methods of study produce greater gains in learning, since the gains may be ranked in increasing magnitude as follows: Control, Fact, Relationship, Generalization.

Analysis of variance of the gains made by the four classes on the fact section of the distribution is shown in Table LI.

TABLE LI

ANALYSIS OF VARIANCE OF THE GAINS IN FACT SUBSCORES FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	49.67	16.557	
Within Groups	89	285.36	3.206	5.164*
Total	92	335.03		

*significant at .01 level.

The F-ratio is significant at the .01 level, indicating that there are significant differences in gains in this area.

Mean difference tests are summarized in Table LII.

TABLE LII

MEAN DIFFERENCE TESTS FOR GAINS IN FACT SUBSCORES FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

	Mean Differences	t	Significance
Generalization and Fact[a]	0.245	0.456	none
Generalization and Relationship	0.483	0.870	none
Generalization and Control	1.906	3.434	$p < .01$
Fact and Relationship	0.238	0.475	none
Fact and Control	1.661	3.315	$p < .01$
Relationship and Control	1.423	2.650	$p < .01$

[a] Difference favors class named first.

In all instances the experimental groups were superior to the Control group in the fact subsection. The training of the Generalization and Relationship groups, while not stressing the learning of facts, produced as much gain in this area as direct practice itself. No differentiation in performance could be made between the classes of the experimental group.

The analysis of the relationship section of the distribution of gains revealed a pattern similar to that for total scores. The F-ratio, as indicated in Table LIII, is significant at the .01 level. In this area the Generalization group showed the greatest gain, being significantly superior in performance to both the Control and the Fact

TABLE LIII

ANALYSIS OF VARIANCE OF THE GAINS IN RELATIONSHIP SUBSCORES FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	63.10	21.03	
Within Groups	89	439.03	4.933	4.26*
Total	92	502.13		

* Significant at the .01 level.

groups. The Relationship gain was greater than both the Fact and the Control groups, although the difference was significant only in the latter case. The Fact group was not significantly better than the Control group in the learning of the relationships. The results of the mean difference tests are presented in Table LIV. In general, these results favor the view that there is an advantage to be gained by learning with meaning. The more meaningful the method of study the

TABLE LIV

MEAN DIFFERENCE TESTS FOR GAINS IN RELATIONSHIP SUBSCORES FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

	Mean Differences	t	Significance
Generalization and Fact	1.835	2.755	$p < .01$
Generalization and Relationship	0.846	1.230	$.2 < p < .3$
Generalization and Control	2.399	3.487	$p < .01$
Relationship and Fact	0.959	1.544	$.1 < p < .2$
Relationship and Control	1.523	2.287	$.01 < p < .05$
Fact and Control	0.564	0.908	$.3 < p < .4$

greater the amount learned. It is worth observing that the Generalization group, which received no training in relationships as defined in this study, made gains comparable to the group receiving specific instruction in this area.

Analysis of covariance with pre-test scores controlled revealed no significant differences in gain in the generalization section of the distribution. The training periods apparently failed to bring about differential performance in the learning of generalizations. In passing it might be noted that the greatest gain appeared to be made by the Generalization group.

Analysis of the subscores made by each of the experimental groups revealed no significant differences in performance. Evidently training in one method of study did not produce differential test performance.

The gains of the Control group in the subsections of the distribution were subjected to the analysis of covariance, with pre-test scores held constant. The results of the analysis are summarized in Table LV.

TABLE LV

ANALYSIS OF COVARIANCE OF THE GAINS IN CONTROL GROUP SUBSCORES FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups Remainder	45	83.06		
Remainder	43	47.09	1.095	
Between Groups	2	36.51	18.255	16.67*

*significant at .01 level.

In this case the relationship and generalization gains were superior to those made in the facts. Inasmuch as the Control group received no special training, these differences cannot be attributed to more than chance experiences on the part of the members of this class that enabled them to perform better on some sections of the test than on others.

In Table LVI, the F-ratios resulting from the analysis of the gains in social studies are presented.

TABLE LVI

F-RATIOS DERIVED FROM THE ANALYSIS OF
GAINS FROM PRE-TEST TO POST-TEST
IN SOCIAL STUDIES, STAGE ONE

	F_{05}	F_{01}	F	Interpretation
Total	2.71	4.00	5.86	$p < .01$
Fact subscores	2.71	4.00	5.16	$p < .01$
Relationship subscores	2.71	4.00	4.26	$p < .01$
Generalization subscores	2.71	4.00	0.45	not significant
Fact group subscores	3.17	5.01	.36	not significant
Relationship group subscores	3.22	5.11	2.976	not significant
Generalization group subscores[a]	-	-	-	-
Control group subscores	3.21	5.12	16.67	$p < .01$

[a] t-tests used, mean differences not significant.

This analysis generally supported the view that the greater the meaningfulness of a method of study, the greater the amount learned. The Generalization group tended to show superior performance, followed in turn by the Relationship and Fact groups.

Summary

The analyses of the gains made from the pre-test to post-test in three subject matter areas revealed certain differential effects of the four training periods. In mathematics, the results were negative. Training in a particular method of study did not produce significant differences in later performance nor any distribution of gains that could be interpreted as a trend. In science a similar pattern of non-significant results was obtained, although on this occasion the distribution of gains appeared to favor the more meaningful methods, that is, the study of material for relationships and generalizations, over the study of material for facts alone. The analysis of the social studies gains showed significant differences in performance on the part of the Generalization group and, to a lesser extent, the Relationship group, the two most meaningful methods employed in the study.

The differential effect of training in the three subject-matter areas may reflect the type of instruction generally associated with these subjects in the classroom. In mathematics, and to a lesser extent in science, much class time is devoted to solving problems, and the application of methods to practical situations. Against this background of experience, it may have been difficult for the Fact and Relationship groups to ignore applications presented in the reading selection and to concentrate on their particular experimental method. This interference from their past experience could have contributed to the negative results in the first two areas investigated.

In the study of social studies, on the other hand, more time is usually devoted to the presentation of facts and less to application of these to meaningful situations. Because of this, the classes would likely be less familiar with the methods used in this investigation, permitting a differentiation in performance to result from the training periods.

From the results of the analysis of gains in social studies it appears that the method of studying material to determine the significant generalizations within it, tends to produce the greatest gains in learning. The case for the generalization method is strengthened when consideration is given to the fact that this group did equally well on the fact section of the test when compared with the group receiving specific training in the learning of facts. In addition, the generalization group showed a greater gain in learning of relationships than did the Relationship group, which had practised on these learning outcomes.

On the whole, results from the analysis of the gains in the three subject matter areas are not well-defined. Conclusions based on these must be considered tentative until confirmation is obtained from the second stage of the experiment.

CHAPTER VIII

TRANSFER IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE ONE

Three weeks after the administration of the post-test each group was given another test in its particular subject-matter area. The purpose of this test was to determine the extent to which the effects of training in a particular method of study would be applied to a new situation after an interval of time. Analysis was carried out on the raw scores, with mental age and pre-test scores controlled where necessary. The results are presented separately for each subject-matter field in the order: mathematics, science and social studies.

Mathematics

The means and standard deviations for the distribution of scores on the transfer test are presented in Table LVII.

TABLE LVII

MEANS AND STANDARD DEVIATIONS, FOR THE TRANSFER TEST IN MATHEMATICS, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	22	11.46	2.56	3.23	1.48	4.23	1.23	4.00	0.98
Relationship	23	11.30	3.04	3.65	1.11	4.17	1.64	3.48	1.41
Generalization	27	15.67	3.19	5.56	1.26	5.33	1.66	4.78	1.26
Control	23	10.96	3.22	3.17	1.62	4.65	1.37	3.13	1.18

One may observe that generally the training periods seem to have produced some effects on performance since in most instances the means of the experimental group exceed those of the control group. It may be noted also that the Generalization group appears to be superior to the other groups on all areas of the test.

After the necessary assumptions had been confirmed, that is, homogeneity of variance and regression coefficients and linearity of regression, analysis of covariance, with mental age and pre-test results held constant, was used to investigate mean differences.

TABLE LVIII

ANALYSIS OF COVARIANCE OF THE TOTAL
SCORES ON THE TRANSFER TEST
IN MATHEMATICS, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	217.08	72.36	
Within Groups	89	720.06	8.09	8.94*
Total	92	937.14		

*Significant at the .01 level

As may be noted from Table LVIII, the F-ratio is significant at the .01 level. After adjustment for the effects of differences in mental age and previous experience, the means for the groups were as follows: Fact, 11.61; Relationship, 12.10; Generalization, 14.70; Control, 11.15. Pairs of adjusted means were then compared by ordinary t-tests to determine areas of difference. The mean score of the Generalization group

was significantly higher than that of any other group. The Relationship group made greater scores than both the Control and the Fact groups, and the Fact group obtained a slightly higher score than the Control group, but none of these differences reached the .05 level of significance. The results of the t-tests are summarized in Table LIX.

TABLE LIX

MEAN DIFFERENCE TESTS FOR THE TOTAL SCORES ON THE TRANSFER TEST IN MATHEMATICS, STAGE ONE

	Adjusted Mean Differences	t	Significance
Generalization and Fact[a]	3.09	3.62	$p < .01$
Generalization and Relationship	2.60	2.91	$p < .01$
Generalization and Control	3.55	4.21	$p < .01$
Relationship and Fact	0.49	0.56	$.5 < p < .6$
Relationship and Control	0.95	1.13	$.2 < p < .3$
Fact and Control	0.46	0.54	$.5 < p < .6$

[a] Difference favors group named first.

The analysis indicates that the effects of the more meaningful method of study are transferred to the greatest extent.

Fact subscores were investigated following the same form of analysis as was used with the total scores, the results being summarized in Table LX. The obtained F-ratio was significant beyond the .01 level.

TABLE LX

ANALYSIS OF COVARIANCE OF THE FACT SUBSCORES ON THE TRANSFER TEST IN MATHEMATICS, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	66.25	22.08	
Within Groups	89	155.23	1.74	12.66*
Total	92	221.48		

*Significant at the .01 level

Adjusted means for each class were as follows: Fact, 3.25; Relationship, 3.93; Generalization, 5.19; Control, 3.30. When these adjusted means were compared by the t-test it was found that again, the only significant differences were between the Generalization group and each of the remaining groups, the former being superior in each instance. These present further evidence of the superiority of the more meaningful method of study.

The relationship subscores were subjected to analysis of covariance, with mental age controlled. The analysis revealed no significant differences in mean scores on this section of the transfer test. Apparent differences, noticeable in Table LVIII, must be attributed to differences in mental age. The method of study stressing the relationships that are found in a reading selection has not been proven to be capable of producing differential performance in mathematics. It should be noted that training with the generalization method also failed to improve the students' ability in this area.

With mental age held constant, analysis of covariance revealed significant differences in performance on the generalization subsection of the transfer test. The F-ratio obtained from this treatment of the data was found to be significant beyond the .01 level. The results of this analysis are given in Table LXI. When the means were adjusted for differences in mental age, the following values were obtained: Fact, 4.01; Relationship, 3.49; Generalization, 4.77; Control, 3.12.

TABLE LXI

ANALYSIS OF COVARIANCE OF THE GENERALIZATION
SUBSCORES ON THE TRANSFER TEST
IN MATHEMATICS, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	25.64	8.55	
Within Groups	90	123.90	1.38	6.21*
Total	93	149.54		

*Significant beyond the .01 level

Mean difference tests, summarized in Table LXII, revealed that the Generalization group was superior to all others, as has been noticed in earlier analyses. In addition, on this occasion the Fact group made a significantly higher score than the Control group. While the difference between the Fact and Relationship groups favored the former, this difference was not significant at the .05 level. The advantage of the Relationship group over the Control group also failed to reach the .05 level of significance.

TABLE LXII

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION SUBSCORES ON THE TRANSFER TEST IN MATHEMATICS, STAGE ONE

	Adjusted Mean Differences	t	Significance
Generalization and Relationship[a]	1.28	3.68	$p < .01$
Generalization and Fact	0.76	2.12	$.01 < p < .05$
Generalization and Control	1.65	4.93	$p < .01$
Fact and Relationship	0.52	1.49	$.1 < p < .2$
Fact and Control	0.89	2.48	$.01 < p < .05$
Relationship and Control	0.37	1.05	$.2 < p < .3$

[a] Difference favors group named first.

Although members of the Fact group varied in their performance on the three sections of the pre-test, differences could not be controlled since regression was found to be non-linear. Analysis of variance indicated differences in performance on the transfer test as well.[2] The analysis is summarized in Table LXIII. Mean difference tests revealed that both the generalization and relationship scores were superior to the fact score. It seems that, when presented with the reading selection for the test, the students in this group were not able to concentrate merely on the facts of the selection, but that prior experience in mathematics caused them to consider the relationships and generalizations as well. It is hardly conceivable that the study of facts alone could produce these results.

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[2] Analysis of covariance revealed the same pattern of results.

TABLE LXIII

ANALYSIS OF VARIANCE OF THE FACT GROUP SUBSCORES ON THE TRANSFER TEST IN MATHEMATICS, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	12.09	6.05	
Subjects	21	45.82		
Remainder	42	51.91	1.24	4.89
Total	65	109.82		

Analysis of the subscores of both the Relationship group and the Generalization group revealed no significant differences. The same result was obtained on the analysis of the gains scores in the previous chapter. After a three-week interval there is no tendency toward differential performance in either of these groups.

The subscores made by the Control group were found to be significantly different when investigated with analysis of variance. The relationship score was superior to both the fact and the generalization score. Since this group received no training in the course of the experiment, these results are likely due to some experiences within the group that made them more favorably disposed toward the learning of relationships than toward the other learning outcomes on this test. The results of the analysis are summarized in Table LXIV.

TABLE LXIV

ANALYSIS OF VARIANCE OF THE CONTROL GROUP
SUBSCORES ON THE TRANSFER TEST
IN MATHEMATICS, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Methods	2	34.52	17.26	
Subjects	22	76.32		
Remainder	44	52.81	1.20	14.39
Total	68	163.65		

The analysis of transfer test results in mathematics generally indicated the superiority of the group using the more meaningful method of study. The Generalization group made higher scores in all areas examined except relationships, where no significant differences were found. A partial explanation for this change in mathematics results from the non-significance noted in the previous chapter to the present clearly significant results, may be found in the activities of the groups during the interval between post and transfer tests. In this period each group received further instruction in its particular method of study, but in a different subject-matter area, namely, science. It is possible that these additional training periods were in part responsible for the differences in performance on the transfer test.

Science

The means and standard deviations for the distribution of scores in science are given in Table LXV. Again it is possible to observe the

[illegible]

[illegible]

	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

general superiority of the generalization group as far as the rank order of raw scores is concerned.

TABLE LXV

MEANS AND STANDARD DEVIATIONS FOR THE TRANSFER TEST IN SCIENCE, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	26	9.85	3.27	3.35	1.13	3.04	1.80	3.46	1.30
Relationship	24	12.38	4.50	4.63	1.31	3.17	2.33	4.58	1.69
Generalization	28	15.00	3.87	4.82	1.25	4.54	2.10	5.64	1.31
Control	16	14.12	3.35	5.13	1.15	4.38	1.75	4.63	1.75

Mean total scores for the four groups were compared using analysis of covariance with mental age and pre-test results held constant. As may be observed in Table LXVI, the F-ratio on this occasion was significant beyond the .01 level. When the means were adjusted for differences in mental age and pre-test performance, the following were obtained: Fact, 10.50; Relationship, 12.63; Generalization, 14.14; Control, 14.21. Mean difference tests for pairs of adjusted means were undertaken and it was found that the Generalization, Relationship and Control groups means were all significantly superior to that of the Fact group. Other differences failed to reach the .05 level of significance. Within the experimental groups the results again suggest an

advantage in favor of the more meaningful methods of study.

TABLE LXVI

ANALYSIS OF COVARIANCE OF THE TOTAL SCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	245.42	81.81	
Within Groups	88	1121.24	12.74	6.42*
Total	91	1366.66		

*Significant at the .01 level

A summary of mean difference tests is given in Table LXVII

TABLE LXVII

MEAN DIFFERENCE TESTS FOR THE TOTAL SCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

	Adjusted Mean Difference	t	Significance
Generalization[a] and Fact	3.64	3.60	$p < .01$
Generalization and Relationship	1.51	1.53	$.1 < p < .2$
Control and Generalization	0.07	0.06	-
Control and Relationship	1.58	1.36	$.1 < p < .2$
Control and Fact	3.71	3.14	$p < .01$
Relationship and Fact	2.13	2.09	$.01 < p < .05$

[a] Difference favors group named first.

Because regression coefficients were not homogeneous, mean subscores in the fact section of the test were examined using simple analysis of variance.[3] The F-ratio obtained with this method was significant beyond the .01 level as is indicated in Table LXVIII.

TABLE LXVIII

ANALYSIS OF VARIANCE OF THE FACT SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	43.46	14.49	
Within Groups	90	133.36	1.48	9.78*
Total	93	176.82		

*Significant at the .01 level.

When these means were compared by the use of t-tests, it was again found that the Generalization, Relationship and Control groups were superior in performance to the Fact group. Within the experimental groups the results again may be interpreted as showing an advantage in learning in favor of a meaningful method of study. The results of the mean difference tests are summarized in Table LXIX.

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[3] Analysis of covariance however, revealed the same pattern of results.

TABLE LXIX

MEAN DIFFERENCE TESTS FOR THE FACT SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

	Mean Difference	t	Significance
Generalization and Fact[a]	1.48	4.41	$p < .01$
Generalization and Relationship	0.20	0.57	$.5 < p < .6$
Control and Generalization	0.30	0.80	$.4 < p < .5$
Control and Relationship	0.50	1.27	$.2 < p < .3$
Control and Fact	1.78	4.59	$p < .01$
Relationship and Fact	1.28	3.74	$p < .01$

[a] Differences favor group named first

The scores on the relationship subsection of the transfer test were subjected to analysis of covariance, with mental age held constant. The resulting F-ratio of 2.68 was almost at the .05 level of significance. Since ordinary analysis of variance had revealed differences in performance, it was decided to proceed with mean difference tests with adjustments made for differences in mental age. The results of the covariance analysis are presented in Table LXX. The adjusted relationship means for the four groups were as follows: Fact, 3.15; Relationship, 3.34; Generalization, 4.18; and Control, 4.57.

TABLE LXX

ANALYSIS OF COVARIANCE OF THE RELATIONSHIP SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	29.62	9.87	
Within Groups	89	327.59	3.68	2.68*
Total	92	357.21		

*Significant at almost .05 level

The Generalization group and the Control group were found to have significantly higher scores than the Fact group. In addition, the Control group showed performance significantly superior to that of the Relationship group. Among the experimental groups, the superiority of the generalization method of study has been maintained in this section of the test. The t-test results are summarized in Table LXXI.

TABLE LXXI

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

	Adjusted Mean Difference	t	Significance
Generalization and Fact[a]	1.03	1.99	$.01 < p < .05$
Generalization and Relationship	0.84	1.59	$.1 < p < .2$
Control and Generalization	0.39	0.65	$.5 < p < .6$
Control and Relationship	1.23	1.99	$.01 < p < .05$
Control and Fact	1.42	2.33	$.01 < p < .05$
Relationship and Fact	0.19	0.35	$.7 < p < .8$

[a] Difference favors group named first

Analysis of covariance was used to investigate mean difference in generalization subscores. Mental age was the only variable held constant since the regression of transfer on pre-test was non-linear. Table LXXII contains the results of this analysis. Since significant differences were evident, individual means were adjusted for differences in mental age and t-tests employed to determine exact areas of difference.

TABLE LXXII

ANALYSIS OF COVARIANCE OF THE GENERALIZATION SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	48.70	16.23	
Within Groups	89	188.37	2.12	7.67*
Total	92	237.07		

*Significant at the .01 level

The adjusted means for the generalization section of the test were: Fact, 3.52; Relationship, 4.67; Generalization, 5.45; and Control, 4.73. On examining pairs of means it was found that the Generalization group had obtained significantly higher scores than the Fact and Relationship groups. In addition, both the Relationship and the Control groups were superior to the Fact group. These results suggest that the learning of generalizations in science is facilitated by a meaningful method of study. The results of the t-tests are given in Table LXXIII.

TABLE LXXIII

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

	Adjusted Mean Differences	t	Significance
Generalization and Fact[a]	1.93	4.90	$p < .01$
Generalization and Relationship	0.78	1.95	$.01 < p < .05$
Generalization and Control	0.72	1.58	$.1 < p < .2$
Relationship and Fact	1.15	2.81	$p < .01$
Control and Relationship	0.06	0.13	$p < .9$
Control and Fact	1.21	2.62	$.01 < p < .05$

[a] Difference favors group named first

Analysis of variance revealed no significant differences in performance on the subsections of the test within either the Fact or the Control group. Since variance was heterogeneous, t-tests were used to investigate subsection scores within the Generalization and Relationship groups. Significant differences were found in both instances. The results of the analysis of the Generalization group are summarized in Table LXXIV.

The scores of the generalization section were higher than those of fact and relationship. This same relative position was noted on the pre-test, and on testing, the differences between the gains of the groups from pre-test to transfer test were found to be non-significant. This would appear to indicate that the effects of training had been transferred

in a uniform manner and that training had not produced differential performance on the transfer test.

TABLE LXXIV

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION GROUP SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

	Mean Differences	t	Significance
Generalization and Relationship[a]	1.107	3.438	$p < .01$
Generalization and Fact	0.822	3.574	$p < .01$
Fact and Relationship	0.285	0.792	$.4 < p < .5$

[a]Difference favors section named first

The results of the examination of the scores made by the Relationships group are contained in Table LXXV.

TABLE LXXV

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP GROUP SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE ONE

	Adjusted Mean Differences	t	Significance
Fact and Relationships[a]	1.458	3.880	$p < .01$
Fact and Generalization	0.042	0.131	$.8 < p < .9$
Generalization and Relationship	1.416	3.320	$p < .01$

[a]Difference favors section named first

This group obtained significantly higher scores in both a fact and generalizations than in relationships, while the difference between the fact and generalization score was not significant. On the pre-test, the generalization score was higher than both fact and relationship, and no significant difference had been found between fact and relationship scores. Analyses of gains from pre-test to transfer test were undertaken to investigate the extent to which training had produced a change in performance on the transfer test. These results indicated that significant gains had been made in facts, producing the differences noted in Table LXXV. The training periods in this group, although emphasizing relationships, had not caused the group to overlook the facts in the selection, but, indeed, had evidently produced an increase in performance in this area of the test. Results of this analysis are summarized in Table LXXVI.

TABLE LXXVI

MEAN DIFFERENCE TESTS FOR GAINS MADE BY THE RELATIONSHIP GROUP FROM THE PRE-TEST TO THE TRANSFER TEST IN SCIENCE, STAGE ONE

	Mean Differences	t	Significance
Fact and Relationship[a]	1.46	2.875	$p < .01$
Fact and Generalization	1.50	3.020	$p < .01$
Relationship and Generalization	0.05	0.088	$p > .90$

[a] Difference favors section named first

In general, the findings of the analysis of the transfer test in science tend to substantiate those of mathematics. The effects of more meaningful methods of study appear to be transferred to new situations to a greater extent than the less meaningful, resulting in higher scores on the transfer test for the groups using these methods.

Inasmuch as no significant differences were found in science with the analysis of gains, it appears that subsequent training periods have had some influence on the performance of this group. In the interval between the post-test and the transfer test this group received training in the same method of study, but in social studies rather than science.

On the basis of transfer test results, the Control class in this group appears to be an exceptional case. Unlike the results found in other analyses, Control group scores in this instance were consistently higher than all except the Generalization group. Since the Control group received no special training in methods of study, these high scores could possibly be the outcome of previous experience with the test material during regular classroom instruction. An alternate and possibly more valid reason for the superior performance of the Control group lies in the fact that throughout the experiment they received normal classroom instruction. This experience would certainly be broader than that of the other classes and likely contained elements of the training received by the three experimental classes. In addition they were not under pressure to use a particular method during the test. These factors could combine to produce higher test results.

If only the experimental groups are considered, the transfer test

in science indicates that the methods of study may be ranked in the order in which the effects of training are transferred. The generalization method appeared consistently superior, followed by the study of relationships, followed in turn by the study of facts.

Social Studies

Means and standard deviations for the distributions of scores made on the transfer test in social studies are presented in Table LXXVII. Observation of the scores would again lead one to suspect the superiority of the Control group.

TABLE LXXVII

MEANS AND STANDARD DEVIATIONS FOR THE TRANSFER TEST IN SOCIAL STUDIES, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	29	10.66	3.30	3.45	1.64	3.62	1.40	3.59	1.74
Relationship	22	12.50	4.75	4.18	1.76	4.09	1.95	4.23	2.02
Generalization	19	14.58	3.29	4.84	1.30	5.10	1.33	4.63	1.67
Control	23	14.78	3.79	5.21	1.35	4.52	1.85	5.04	1.43

Mean total scores on the test were investigated by analysis of

covariance, with pre-test scores constant. The F-ratio obtained in this way was significant at the .01 level, indicating differences in performance beyond the bounds of chance. The summary of the analysis appears in Table LXXVIII. On making adjustments for initial differences in performance, the following means were obtained: Fact, 11.66; Relationship, 12.25; Generalization, 15.12; and Control, 13.28.

TABLE LXXVIII

ANALYSIS OF COVARIANCE OF THE TOTAL
SCORES ON THE TRANSFER TEST IN
SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Adjusted Sum of Squares	Variance Estimate	F
Between Groups	3	149.83	49.94	
Within Groups	88	777.29	8.83	5.65*
Total	91	927.12		

*Significant at the .01 level

Mean difference tests reported in Table LXXIX revealed that the Generalization group surpassed both the Fact and the Relationship groups in total test performance. The difference favoring the Generalization group over the Control group almost reached the .05 level of significance. These results are in keeping with those of the transfer tests reported earlier, in which the superiority of the Generalization group was noted.

TABLE LXXIX

MEAN DIFFERENCE TESTS FOR THE TOTAL SCORES ON THE TRANSFER TEST IN SOCIAL STUDIES, STAGE ONE

	Adjusted Mean Difference	t	Significance
Generalization and Fact [a]	3.46	3.95	$p < .01$
Generalization and Relationship	2.87	3.07	$p < .01$
Generalization and Control	1.84	1.92	$.05 < p < .1$
Control and Relationship	1.03	1.15	$.2 < p < .3$
Control and Fact	1.62	1.83	$.05 < p < .1$
Relationship and Fact	0.59	0.69	$.4 < p < .5$

[a] Differences favor group named first

Since pre-test scores and mental ages did not differ, simple analysis of variance was employed to examine scores on the fact section of the test. An F-ratio significant beyond the .01 level indicated differential performance in this area. The results of the analysis are contained in Table LXXX.

TABLE LXXX

ANALYSIS OF VARIANCE OF THE FACT SUBSCORES ON THE TRANSFER TEST IN SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	46.11	15.37	
Within Groups	89	210.88	2.37	6.49*
Total	92	256.99		

*Significant at the .01 level

Using the t-test to compare pairs of means, it was found that the Generalization group made a significantly higher score than the Fact group and that the Control group was significantly better than both the Relationship and Fact groups on this section of the test. The t-tests are summarized in Table LXXXI. Again it may be noted that the group trained to studying material to determine the important generalizations within it showed greater evidence of transfer to new situations than did groups following less meaningful methods. The advantage in social studies was less clear-cut than it was in mathematics or science, however.

TABLE LXXXI

MEAN DIFFERENCE TESTS FOR THE FACT SUBSCORES ON THE TRANSFER TEST IN SOCIAL STUDIES, STAGE ONE

	Mean Differences	t	Significance
Generalization and Fact[a]	1.39	3.02	$p < .01$
Generalization and Relationship	0.66	1.38	$.1 < p < .2$
Control and Fact	1.77	4.11	$p < .01$
Control and Relationship	1.04	2.24	$.01 < p < .05$
Control and Generalization	0.38	0.79	$.4 < p < .5$
Relationship and Fact	0.73	1.71	$.05 < p < .1$

[a] Difference favors group named first

Performance on the relationship section of the transfer test was investigated by means of analysis of variance. The F-ratio, significant

at the .05 level, revealed that the groups differed significantly. Table LXXXII contains the results of this analysis. When pairs of means were compared, the Generalization group once more was found to be significantly higher than the Fact group. No other differences reached the .05 level, although the superiority of the Generalization group over the Relationship group and the Control group over the Fact group was very nearly significant as may be noted in Table LXXXIII.

TABLE LXXXII

ANALYSIS OF VARIANCE OF THE RELATIONSHIP
SUBSCORES ON THE TRANSFER TEST IN
SOCIAL STUDIES, STAGE ONE

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	27.63	9.21	
Within Groups	89	242.18	2.72	3.38*
Total	92	269.81		

*Significant at the .05 level

This analysis gives further confirmation to the view that a more meaningful method of study results in a higher degree of transfer than a method that is less meaningful.

Analysis of covariance, controlling pre-test scores, failed to reveal significant differences in generalization subscores. The effects of training in a particular method of study did not transfer to the generalization section of this test. This finding is in contrast to that of both the Mathematics and Science transfer tests, where the more

meaningful methods evidenced greater transfer.

TABLE LXXXIII

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP SUBSCORES ON THE TRANSFER TEST IN SOCIAL STUDIES, STAGE ONE

	Mean Difference	t	Significance
Generalization and Fact[a]	1.48	2.99	$p < .01$
Generalization and Relationship	1.01	1.97	$.05 < p < .1$
Control and Generalization	0.58	1.13	$.2 < p < .3$
Control and Relationship	0.43	0.87	$.3 < p < .4$
Control and Fact	0.90	1.95	$.05 < p < .1$
Relationship and Fact	0.47	1.02	$.3 < p < .4$

[a] Difference favors group named first

Investigation of the subtest performance of the members of each of the groups by means of analysis of variance or analysis of covariance did not disclose any significant differences. These results are comparable to those found in the science transfer test, and in the Relationship and Generalization groups in mathematics.

Summary

This chapter has presented the analysis of the performance of the three subject-matter groups on transfer tests similar in structure to the pre-test and post-test given to each group and equated with the subject-matter tests in degree of difficulty. The transfer test was

administered twenty-one days after the post-test, during which time no training was received in the original subject-matter. In the interval between the post-test and the transfer test, each class was tested and received instruction from the experimenter in its original method of study, but in a different subject-matter area. Performance on the present transfer tests, without doubt, reflect this additional training.

In the science and social studies tests the Control group may have been more familiar with the materials on which the tests were based than were the experimental groups. Their consistently high scores on all sections of the test more likely were the results of their regular classroom instruction which would likely include practice in the study of material for facts, relationships and generalizations. These experiences would tend to produce higher test performance than the emphasis on a restricted method of study that was used with the experimental group.

The analysis of the total scores on the three transfer tests revealed that the Generalization group made significantly higher scores than the other experimental groups in mathematics, science and social studies. In both mathematics and science the Relationship group was superior to the Fact group.

On the fact section of the test, the Generalization group was superior to the Fact group in the three subject-matter areas. In mathematics, the Generalization group also surpassed the Relationship group. In addition, in one instance, science, the Relationship group was superior to the Fact group.

Analysis of the relationship section of the test disclosed that the Generalization group again surpassed the Fact group in science and

social studies. In mathematics no differences were found in this area of the test.

The Generalization and the Relationship groups made significantly higher scores than the Fact group in the generalization section of the science transfer test. On this test also, the Generalization group was superior to the Relationship group. In both mathematics and social studies no differences were noted in this area.

Differential subtest performance within a particular class was found in mathematics and science. In mathematics, the Control group made higher scores in relationships than in facts or generalizations. On this test also the Fact group made higher scores in relationships and generalizations than in the fact section.

In the Relationship group, in science, superior performance appeared in the fact section over the generalization and relationship sections. While the Generalization group made higher scores in generalizations than in facts or relationships, it seemed that this difference could be attributed to pre-test performance which was not controlled in the analysis.

On the whole, there does not appear to be a trend in the within-group performance on the transfer tests.

From the results of the analysis described in this chapter it appears that training in a method of study involving the reading of a selection to determine the important generalizations within it leads to greater transfer than does the study of material for facts or relationships. Evidence seems to indicate that this conclusion may be generalized to cover the three subject-matter areas investigated.

In other words, it appears that for the students taking part in this experiment the effects of training are transferred to a higher degree if the method of study employed emphasizes meaning in learning.

CHAPTER IX

RETENTION IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE ONE

To determine the effects of a passage of time on the retention of materials learned after training in one of the experimental methods of this investigation, the multiple-choice test, given as part of the post-test in each subject matter area, was administered again after a twenty-one-day interval. Scores made on the retention test were subtracted from post-test scores to obtain a distribution of losses. It should be noted that in this distribution, low scores indicate superior retention.

Analyses of variance and covariance were used throughout the examination of the retention scores. Underlying assumptions were tested in each instance, before using either technique. As in other chapters, results are again presented separately for each subject matter group and in the order: mathematics, science and social studies.

Mathematics

Means and standard deviations for the retention scores are presented in Table LXXXIV.

TABLE LXXXIV

MEANS AND STANDARD DEVIATIONS FOR
RETENTION SCORES IN MATHEMATICS, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M.	S.D.	M.	S.D.	M.	S.D.	M.	S.D.
Fact	22	0.73	2.93	0.50	1.62	0.05	2.08	0.18	1.35
Relationship	23	1.26	3.05	1.48	1.08	-0.13	1.66	0.09	1.28
Generalization	27	0.59	3.55	0.37	1.27	0.26	1.93	-0.04	1.93
Control	23	0.52	2.79	-0.22	1.98	0.09	1.65	0.65	1.64

Analysis of variance of the total scores revealed no significant differences. It would appear that, in mathematics, the training periods were insufficient to produce variations in retention.

The variance of the distribution of fact scores was found to be heterogeneous; consequently mean differences were examined using the Cochran and Cox technique. The results of this analysis are presented in Table LXXXV.

TABLE LXXXV

MEAN DIFFERENCE TESTS FOR THE FACT SUBSCORES
IN RETENTION IN MATHEMATICS, STAGE ONE

	t'05	t'01	t
Relationship and Fact[a]	2.078	2.827	2.312
Fact and Generalization	2.810	2.065	0.302
Fact and Control	2.076	2.826	1.300
Relationship and Generalization	2.069	2.793	3.259
Relationship and Control	2.074	2.818	3.530
Generalization and Control	2.809	2.071	1.198

[a] Difference favors group named first.

On this section of the test the Generalization, Fact and Control groups showed superior retention when compared with the Relationship group. No other significant differences were found. In mathematics, a method of study emphasizing relationships and excluding a direct consideration of facts appears to adversely influence the recall of facts at a later date.

Analysis of the relationship and generalization subscores did not disclose any significant mean differences. In addition, subjective examination of the distribution of means failed to reveal a trend in either area. Four periods of training in mathematics did not bring about differential performance on the retention test.

On the examination of sub-test performance within each subject matter group, significant differences were found only in the case of the Relationship group. The comparison of mean scores, summarized in Table LXXXVI, revealed that the members of this group remembered significantly fewer facts than they did relationships and generalizations. In mathematics, on the basis of these results, studying material to

TABLE LXXXVI

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP GROUP SUBSCORES IN RETENTION IN MATHEMATICS, STAGE ONE

	Mean Difference	D05[a]	D01
Fact and Relationship[b]	1.61	0.669	0.893
Fact and Generalization	1.39	0.669	0.893
Generalization and Relationship	0.22	0.669	0.893

[a] Difference must exceed Table Value to be significant at the .05 level.

[b] Difference favors section named first.

determine the important relationships apparently does not produce improvement in the less meaningful outcomes, namely, the retention of facts.

In viewing the analysis of the retention test as a whole, it appears that the training periods produced little effect on the retention of facts, relationships and generalizations. Apart from the single instance of poorer recall of facts by the Relationship group, no significant differences were found.

Science

Means and standard deviations for retention scores in science are summarized in Table LXXXVII.

TABLE LXXXVII

MEANS AND STANDARD DEVIATIONS FOR RETENTION SCORES IN SCIENCE, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M.	S.D.	M.	S.D.
Fact	26	2.39	3.88	1.12	1.86	1.92	1.77	0.08	1.76
Relationship	24	1.67	2.66	0.54	1.69	0.54	1.38	0.58	1.44
Generalization	28	1.36	3.13	0.61	1.50	0.86	1.80	-0.11	1.71
Control	16	2.06	3.73	-0.25	2.08	1.50	1.97	0.81	1.68

Since regression was found to be non-linear, mean total scores were analyzed using simple analysis of variance. As in the case of mathematics, no significant differences were found. Training for four periods in different methods of study did not produce differential retention in science as measured by total scores.

The examination of the means of the four classes in each of the subsections of the test, fact, relationship and generalization, also failed to disclose instances of significant differences. No method of study employed in the experiment produced an advantage in retention in any of the learning outcomes tested.

Analysis of variance of Fact group scores on the three sections of the distribution resulted in a significant F-ratio. On the examination of the pairs of means, it was found that the members of this class retained significantly more generalizations than they did facts and relationships. Mean difference test results are summarized in Table LXXXVIII.

TABLE LXXXVIII

MEAN DIFFERENCE TESTS FOR THE FACT GROUP SUBSCORES IN RETENTION IN SCIENCE, STAGE ONE

	Mean Difference	D_{05}[a]	D_{01}
Fact and Relationship	0.770	0.860	1.147
Fact and Generalization	1.038	0.860	1.147
Relationship and Generalization	1.115	0.860	1.147

[a] Difference must exceed Table Value to be significant at the .05 level.

[b] Difference favors section named first.

Since this group received training in a method stressing the facts in a selection and not considering either relationships or generalizations, it would seem that the successful recall of the latter was due to experience outside the experimental situation.

The Control group also showed evidence of variable performance on

the retention test. The F-ratio obtained through analysis of variance was significant beyond the .05 level. Mean difference tests, summarized in Table LXXXIX, revealed that the Control group retained significantly more facts than it did relationships. No other differences were significant. As this group received no special training, the differences in performance may be attributed to experiences in learning in the regular classroom.

TABLE LXXXIX

MEAN DIFFERENCE TESTS FOR THE CONTROL GROUP SUBSCORES IN RETENTION IN SCIENCE, STAGE ONE

	Mean Difference	D_{05}[a]	D_{01}
Relationship and Generalization[b]	0.687	1.297	1.746
Relationship and Fact	1.750	1.297	1.746
Generalization and Fact	1.063	1.297	1.746

[a] Difference must exceed Table Value to be significant at the .05 level.

[b] Differences favor section named first.

Analysis of the subsection scores of the Relationship and the Generalization group did not disclose any significant difference in performance. Training in reading material for generalizations or relationships did not produce variation in retention of the learning outcomes examined in this experiment.

On the whole the results of the analysis of retention scores in science are similar to those in mathematics. Except for within group variation on the part of the Control and Fact groups, the training experienced by the classes in three different methods of study failed to produce differences in retention over a twenty-one day interval.

Social Studies

Means and standard deviations for the distribution of retention scores in social studies are presented in Table XC.

TABLE XC

MEANS AND STANDARD DEVIATIONS FOR RETENTION SCORES IN SOCIAL STUDIES, STAGE ONE

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	29	1.79	2.78	1.24	1.97	0.07	1.65	0.48	1.50
Relationship	22	0.73	2.91	0.91	1.38	-0.23	1.80	0.05	1.73
Generalization	19	1.95	3.41	0.84	1.42	0.00	1.20	1.11	1.45
Control	23	0.61	3.36	0.13	2.01	0.35	1.77	0.13	1.46

In examining the total scores of the distribution, regression was found to be non-linear, necessitating the use of simple analysis of variance. The F-ratio did not reach the .05 level of significance, indicating that there were no significant differences in mean total scores on this test. In social studies, as in mathematics and science, the training periods in methods of study failed to produce variation in performance on the retention tests, as far as could be determined from the total scores.

Analysis of the fact, relationship and generalization subsections of the distribution did not reveal any significant differences between means. After four training periods, the methods of study employed in this investigation did not result in superior retention on the part of any of the groups.

No significant differences were found between mean scores on the subsections of the distribution for either the Control group or the Relationship group. The training received by the Relationship group evidently was not sufficient to produce differential performance on the retention test. The homogeneity of mean scores within the Control group suggests that the pupils did not have any experiences in the course of their regular classroom activities that would promote retention of social studies in one of the areas, fact, relationship or generalization, rather than another.

When the retention scores of the Fact group were subjected to analysis of variance, a significant F-ratio was obtained. Mean difference tests, summarized in Table XCI, disclosed that the members of this group retained significantly more relationships than facts. As the training for this group stressed the identification of important facts in a selection, and no consideration was given to either generalizations or relationships, it seems unlikely that the differences in results can

TABLE XCI

MEAN DIFFERENCE TESTS FOR THE FACT GROUP
SUBSCORES IN RETENTION IN SOCIAL STUDIES, STAGE ONE

	Mean Difference	D_{05}[a]	D_{01}
Fact and Relationship[b]	1.171	0.922	1.230
Fact and Generalization	0.757	0.922	1.230
Generalization and Relationship	0.414	0.922	1.230

[a] Difference must exceed Table Value for significance at the .05 level.

[b] Differences favor section named first.

be attributed to the training periods. It may be, however, that even with training, the facts of a selection, learned without consideration for their meaning are not well retained.

Analysis of the scores made by the Generalization group on the subsections of the test revealed significant differences in performance. Table XCII contains the results of the mean difference tests.

TABLE XCII

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION GROUP SUBSCORES IN RETENTION IN SOCIAL STUDIES, STAGE ONE

	Mean Difference	D_{05}[a]	D_{01}
Fact and Relationship[b]	0.842	0.812	1.008
Generalization and Relationship	1.105	0.812	1.008
Generalization and Fact	0.263	0.812	1.008

[a] Difference must exceed Table Value to be significant at the .05 level.

[b] Difference favors section named first.

The members of the Generalization group displayed significantly greater retention of relationships than they did of generalizations and facts. The four practice periods apparently were insufficient to produce uniform retention of the material in the reading selection in social studies.

On the whole, the analysis of the distribution of retention scores in social studies reflected the pattern observed in mathematics and science. With the exception of the variation in the subsections of the Fact and Generalization groups, no significant differences were found. The training periods in social studies failed to produce superiority in

retention on the part of any of the methods of study employed in the experiment.

Summary

Analysis of the total retention scores for the three subject matter groups did not reveal any significant differences among the groups trained in different methods of study. With one exception, the same results were found when the three subsections of the distributions, fact, relationship and generalization, were examined. The exception occurred in the fact section of the mathematics test where the Fact, Generalization and Control groups showed significantly greater retention than did the Relationship group.

There was some variation of performance within certain classes in all subject matter groups. In mathematics, the Relationship group remembered fewer facts than it did relationships and generalizations. The Fact group, in science, retained more generalizations than relationships and facts. In addition, in science, the Control group recalled significantly more facts than it did relationships. The Fact and Generalization groups in social studies exhibited differential retention, the former being better in relationships than facts, and the latter, better in relationships than in both facts and generalizations.

Generally, the results of the analysis of retention scores were negative. No method of study employed in the four training periods appeared to favor the retention of material more than another.

CHAPTER X

A SUMMARY OF THE FINDINGS OF STAGE ONE IN LEARNING, TRANSFER AND RETENTION

Stage one of the experiment included the test and training periods involving the first subject matter area assigned to each class. A pre-test was first administered to all classes to determine their familiarity with the methods employed in the study. This was followed by four thirty-five minute periods in which the three experimental classes in each subject matter group received training in the study of material for facts, relationships and generalizations. A post-test was then administered to find the extent to which performance had been influenced by the training periods. Twenty-one days later, the post-test was re-administered as a delayed retention test. In this period also, the transfer test was given to measure the degree to which the effects of training were applied to a new situation after the lapse of a period of time.

In the course of the treatment of the data from stage one, analyses were made of the distribution of gains from pre-test to post-test, the performance on the transfer test, and the distribution of losses from post-test to retention test. The results of these analyses are presented, in summary form, in this chapter.

Gains From Pre-test to Post-test

Mathematics

Analysis of the distribution of gains from pre-test to post-test

revealed no significant differences among the groups. Within the Fact group, gains made in the fact and generalization sections were significantly greater than those made in relationships. In the Generalization group, gains in fact were greater than gains in relationships and generalizations.

Science

In science, the analyses also disclosed non-significant differences in mean gains among the groups. In addition, the investigation of the performance within each of the groups failed to reveal significant differences. Inspection of the distribution of gains, however, showed a trend that appeared to favor the more meaningful methods of study.

Social Studies

The Generalization group made significantly greater gains in mean total score in social studies than did the Fact or Control groups. The Relationship group also showed significantly greater gains than the Control group. The superiority of the Generalization group over the Relationship group, and the Relationship over the Fact group approached, but did not reach the .05 level of significance.

On the fact section of the distribution, all experimental groups were superior to the Control group beyond the .01 level of significance. The analysis of gains in relationship revealed significantly better performance on the part of the Generalization group over the Control and Fact groups. The Relationship group was also significantly higher than the Control group. No significant differences were found on the analysis of the generalization section of the distribution.

The only variation noted within any of the groups occurred with the Control group where gains in relationships and generalizations exceeded those made in facts.

Summary

In the area of social studies, the results of the analyses of gains indicate that training in a more meaningful method, that of generalizations, produces greater gains than does training in the less meaningful method, the study of facts. This tentative conclusion cannot be generalized since results from the other two subject matter areas were negative. The pattern of non-significance resulting from the analysis of performance within each group in the three subject matter areas, suggests that gains were made uniformly in fact, relationship and generalization.

Transfer

Mathematics

On total test performance in mathematics, the Generalization group was found to be significantly higher than the other three groups. The same result was obtained from the analyses of the fact and the generalization subsections of the transfer test. In addition, in the latter instance, the Fact group made a significantly higher score than the Control group. No significant differences were found in the analysis of the relationship subsection of the test.

Within the Fact group, significantly higher scores were made in the area of generalizations and relationships than in facts. Superior performance on the part of the members of the Control group was noted

in the area of relationships as compared with both facts and generalizations. No differences were found within the Relationship and Generalization groups.

Science

The Generalization, Relationship and Control groups obtained significantly higher total scores than the Fact group in science. The same results were obtained on the analysis of the fact section of the transfer test. In the area of relationships, the Generalization and Control groups showed performance significantly superior to that of the Fact group. The Control group in this case was also significantly higher than the Relationship group. A significantly greater score was made by the Generalization group than either the Fact or Relationship group on the generalization section of the transfer test. In addition, in this area, both the Relationship and Control groups were superior to the Fact group.

Within the Relationship group, it was found that the effects of training had been most marked in the fact section of the test. Analyses of variance revealed that the members of the Generalization group had made higher scores in the area of generalizations than in relationships and facts. Since it was not possible to control pre-test scores in this area, gains from the pre-test to the transfer test were examined. These differences were found to be non-significant, indicating that the training periods had not produced differential performance on the transfer test. There were no significant differences within the Control group or the Fact group.

Social Studies

The Generalization group achieved a significantly higher mean total score in social studies than both the Fact and the Relationship groups. On the fact section of the test, the Generalization and the Control groups made significantly higher scores than the Fact group. The Control group, in this instance, also was superior to the Relationship group beyond the .05 level of significance. The difference between the Generalization group and the Fact group, favoring the former, was significant beyond the .01 level on the relationship section of the test. No significant differences were noted on the analysis of the generalization section of the test.

The analysis of the performance on the subsections of the test by members within each group revealed no significant differences.

Summary

The results of the analyses of the scores made on the transfer tests seem to indicate that the study of materials for generalizations led to greater transfer than did the study of material for relationships and facts. Under the conditions of the present experiment, then, it appears that the effects of training in the more meaningful method of study are transferred to a greater extent than those of less meaningful methods.

The analysis of the performance of each group on the subsections of the test revealed few significant differences. This indicates a uniformity in the transfer of the effects of training in a particular method to the areas of fact, relationship and generalization.

Retention

Mathematics

The analyses of mean total scores in mathematics revealed no significant differences. On the fact section of the test, the Generalization, Fact and Control groups were found to be significantly superior to the Relationship group. The examination of the relationship and generalization sections of the distribution failed to produce significant differences. The only group showing variation in performance on the subsections of the test was the Relationship group. The members of this group retained significantly more generalizations and relationships than they did facts.

Science

Analyses of total scores as well as those obtained on the fact, relationship and generalization subsections of the test failed to reveal significant differences in retention. Within the Fact group, significantly greater retention was noted for generalizations and relationships than for facts. The Control group, on the other hand, showed superior retention of facts when compared with relationships. Differences within the Relationship and Generalization groups did not reach the .05 level of significance.

Social Studies

In social studies, as in science, analyses of total scores and scores of the fact, relationship and generalization sections of the test revealed no significant differences in performance. Within the Fact group, significantly more relationships than facts were retained. The

members of the Generalization group showed greater retention of relationships than either generalizations or facts. No significant differences were obtained when the subscores of the Relationship group and Control group were examined.

Summary

In general, analyses of the distributions of retention scores failed to establish the superiority of any of the methods of study involved in this experiment.

Although there was some variation within the classes, no pattern was found that would permit the evaluation of the effects of training on the retention of facts, relationships and generalizations by the members of a class.

Tentative Conclusions

On the basis of the analyses of the results of stage one, certain conclusions are presented, tentative in nature, pending the results of stage two of the experiment.

1. In the area of social studies, training in the more meaningful method of generalizations, tended to produce greater gains in learning than did the less meaningful methods of relationships and facts. Results from the analysis of mathematics and science were inconclusive.
2. Within each of the classes involved in this experiment, gains appeared to be made uniformly in the areas of facts, relationships and generalizations, since in only two instances were significant differences obtained.
3. The analysis of the transfer test revealed that, in general, the

effects of training in the more meaningful method of study, that is, the study of material for generalizations, appeared to be transferred to a greater extent than did the effects of training in less meaningful methods, those of facts and relationships.

4. The effects of training appeared to be transferred uniformly in the areas of fact, relationship and generalization within each of the classes. In all but three instances no significant differences were found.

5. Investigation of retention failed to reveal the superiority of any of the methods of study employed in this investigation.

6. The results of the analyses of the performance of members within each of the classes were inconclusive. The effects of training upon retention, therefore, could not be determined in stage one of the experiment.

CHAPTER XI

ANALYSIS OF MENTAL AGE AND PRE-TEST RESULTS IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE TWO

During the period following the post-test in the first subject matter area, the second stage of the experiment was started. Each class repeated the procedures used in the first part of the experiment, receiving training in the same method of study, but working in a different subject matter field.

Because training received in the first stage of the experiment would influence performance on the tests in the second, only those students who had completed all training periods and tests were included as subjects for the final analyses. This restriction, although necessary, greatly reduced the number of cases in a class in some instances. As a result of this, a re-examination of the distributions of mental age was undertaken to determine the extent to which this variable would have to be controlled in subsequent statistical analyses. This investigation of mental ages constitutes the first section of the present chapter.

The results of a pre-test administered in the second subject matter area were also examined. The analysis in this case served two purposes: first, the extent to which performance on this pre-test should be controlled in later investigations of learning, transfer and retention was determined; second, holding initial pre-test constant, the degree to which the effects of training in a particular method of study were transferred to a different subject matter area was found. This analysis constitutes the second section of the chapter.

Mental Age

A summary of mean mental ages for the classes of each subject matter group is presented in Table XCIII.

TABLE XCIII

STANDARD DEVIATIONS AND MEAN MENTAL AGES IN MONTHS FOR EXPERIMENTAL AND CONTROL CLASSES, STAGE TWO

	n	Mean	Standard Deviation
Social Studies - Mathematics Group:			
Fact Class	21	159.57	22.46
Relationship Class	18	171.44	22.43
Generalization Class	12	171.67	13.67
Control Class	21	160.43	22.97
Science - Social Studies Group:			
Fact Class	21	155.52	18.26
Relationship Class	19	156.58	18.15
Generalization Class	19	169.47	13.98
Control Class	15	153.20	12.28
Mathematics - Science Group:			
Fact Class	20	161.40	13.50
Relationship Class	14	160.64	14.01
Generalization Class	21	170.00	17.10
Control Class	19	157.05	18.41

The application of Hartley's test revealed that the variances of the distribution of mental ages were homogeneous. Analysis of variance indicated that there were differences in mental ages among the twelve classes. To determine the extent to which mental age would need to be controlled during the second stage of the study, the distributions for each subject matter group were treated separately, using analysis of variance in each instance. The results for the Social Studies - Mathematics group are presented in Table XCIV.

TABLE XCIV

ANALYSIS OF VARIANCE OF THE MENTAL AGES FOR THE SOCIAL STUDIES-MATHEMATICS GROUP IN STAGE TWO

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	2,335.89	778.63	
Within Groups	68	31,245.39	459.49	1.70
Total	71	33,581.28		

The F-ratio failed to reach the .05 level of significance, consequently mental ages need not be controlled in later statistical treatments of the data for this group.

The same conclusion was drawn from the analysis of mental ages for the Mathematics - Science group, summarized in Table XCV.

TABLE XCV

ANALYSIS OF VARIANCE OF THE MENTAL AGES FOR THE MATHEMATICS-SCIENCE GROUP IN STAGE TWO

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	1,817.05	605.68	
Within Groups	70	17,962.96	256.61	2.36
Total	73	19,780.01		

The treatment of the data for the Science - Social Studies group, on the other hand, produced an F-ratio significant at the .05 level. This analysis is reported in Table XCVI. The classes in this group differed in mental age and as a result, this variable must be held constant in later treatments of the data. Although mean differences were not tested, it would appear from Table XCIII that the Generalization class was significantly higher in mental age than the other classes.

TABLE XCVI

ANALYSIS OF VARIANCE OF THE MENTAL AGES FOR THE SCIENCE-SOCIAL STUDIES GROUP IN STAGE TWO

Source of Variation	df	Sum of Squares	Variance Estimate	F
Between Groups	3	2,953.33	984.44	
Within Groups	70	18,235.01	260.50	3.78*
Total	73	21,188.34		

*Significant at the .05 level.

The examination of mental age distributions for the three subject matter groups indicated that this variable should be controlled in subsequent analyses of the Science - Social Studies group. No differences were found in either the Social Studies - Mathematics group or the Mathematics - Science group.

Pre-Test Results, Stage Two

The analysis of pre-test scores follows the same pattern as in previous chapters. Each subject matter group is considered separately and is reported in the order: mathematics, science and social studies.

Mathematics

The means and standard deviations for the four classes of the Social Studies - Mathematics group in the mathematics pre-test are summarized in Table XCVII.

TABLE XCVII

MEANS AND STANDARD DEVIATIONS FOR THE PRE-TEST IN MATHEMATICS, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	8.95	3.34	4.05	1.39	2.29	1.31	2.62	1.66
Relationship	18	9.17	3.69	4.50	1.66	2.83	1.34	1.83	1.58
Generalization	12	13.00	4.00	6.08	1.38	4.16	2.29	2.75	1.60
Control	21	10.90	2.57	4.48	1.57	3.52	1.48	2.90	1.36

Analysis of covariance of the total scores, with initial pre-test results held constant, revealed that there were differences among the classes in performance on the second pre-test. The results of this analysis are contained in Table XCVIII.

TABLE XCVIII

ANALYSIS OF COVARIANCE OF THE TOTAL SCORES ON THE PRE-TEST IN MATHEMATICS, STAGE TWO

Source of Variation	df	Sum of Squares	Estimate of Variance	F
Between Groups	3	161.83	53.94	
Within Groups	67	641.29	9.57	5.64*
Total	70	803.12		

*Significant beyond the .01 level.

After adjusting for differences in initial ability in the methods employed in this study, the means for the classes were as follows: Fact, 9.59; Relationship, 8.94; Generalization, 13.46; and Control, 10.20. Mean differences were investigated by means of t-tests, the results of which are found in Table XCIX. The Generalization group was found to have a total score significantly higher than that of the other three groups. These differences were the only significant mean differences discovered.

TABLE XCIX

MEAN DIFFERENCE TESTS FOR TOTAL SCORES ON
THE PRE-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	t	Significance
Generalization and Fact[a]	3.87	3.46	$p < .01$
Generalization and Relationship	4.52	3.86	$p < .01$
Generalization and Control	3.26	2.80	$p < .01$
Control and Fact	0.61	0.59	$.5 < p < .6$
Control and Relationship	1.26	1.25	$.2 < p < .3$
Fact and Relationship	0.65	0.63	$.5 < p < .6$

[a]Difference favors group named first.

The results of the analysis indicate that pre-test results should be controlled in analysis of the later performance of this group. In addition, the superiority of the Generalization group suggests that the effects of the more meaningful method of study are transferred from one subject matter area to another to a greater extent than are those of less meaningful methods.

Analysis of variance of the fact subscores for the mathematics test produced a significant F-ratio, indicating differences in performance in this section of the test. Pairs of means were then examined with the t-test to determine specific differences. The results, shown in Table C, again disclosed that the Generalization group had obtained a significantly higher score than any other group. As in the previous analysis, there were no other significant differences. Because of these differences, the scores on the fact section of the pre-test must be held constant in later analyses. Again, the effects of training in the generalization method appear to be transferred to a higher degree than the effects of training in the fact or relationship method.

TABLE C

MEAN DIFFERENCE TESTS FOR THE FACT SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	t	Significance
Generalization and Fact[a]	2.03	3.73	$p < .01$
Generalization and Relationship	1.58	2.82	$p < .01$
Generalization and Control	1.60	2.94	$p < .01$
Relationship and Fact	0.45	0.92	$.3 < p < .4$
Relationship and Control	0.02	0.04	$.9 < p$
Control and Fact	0.43	0.92	$.3 < p < .4$

[a] Difference favors the group named first.

The examination of relationship subscores indicated differential performance on the part of the classes in this group. These scores, too, must be held constant during subsequent treatment of results in mathematics. Mean difference tests, summarized in Table CI showed that the Generalization group obtained significantly higher scores than either the

TABLE CI

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	t	Significance
Generalization and Fact[a]	1.87	3.37	$p < .01$
Generalization and Relationship	1.33	2.33	$.01 < p < .05$
Generalization and Control	0.64	1.15	$.2 < p < .3$
Control and Fact	1.23	2.57	$.01 < p < .05$
Control and Relationship	0.69	1.40	$.1 < p < .2$
Relationship and Fact	0.54	1.10	$.2 < p < .3$

[a] Difference favors group named first.

Fact or the Relationship group. The difference between the Generalization and Control groups favored the former but did not reach significance. In this instance, also, the Control group was significantly better in performance than the Fact group. On the whole, the results of the analysis tend to substantiate the findings of the previous sections, namely, the more meaningful the method of study, the greater the degree of transfer.

Generalization subscores revealed no significant differences on analysis of variance, making it unnecessary to control these scores in later analyses.

With pre-test scores from stage one held constant, analysis of covariance yielded a significant F-ratio. After adjustment for difference in initial test performance, the following means resulted: Fact, 2.89; Relationship, 1.66; Generalization, 3.00; and Control, 2.63. The results of comparisons of pairs of means by the t-test are shown in Table CII.

TABLE CII

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	t	Significance
Generalization and Fact	0.11	0.21	$.8 < p < .9$
Generalization and Relationship	1.34	2.41	$.01 < p < .05$
Generalization and Control	0.37	0.68	$.4 < p < .5$
Fact and Relationship	1.23	2.53	$.01 < p < .05$
Fact and Control	0.26	0.54	$.5 < p < .6$
Control and Relationship	0.97	2.08	$.01 < p < .05$

[a] Difference favors groups named first.

On this section of the test the Fact, Generalization and Control groups all made significantly higher scores than the Relationship group. No other differences were found to be significant. Training in more meaningful methods of study failed to produce superiority in transfer in this instance.

The analysis of the subsection scores within each group revealed variation in performance in all but the Control group. Mean difference tests for the Fact group are presented in Table CIII.

TABLE CIII

MEAN DIFFERENCE TESTS FOR THE FACT GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Fact and Relationship[b]	1.76	0.728	0.973
Fact and Generalization	1.43	0.728	0.973
Generalization and Relationship	0.33	0.728	0.973

[a] Difference must exceed Table Value to be significant at the .05 level.
[b] Difference favors section named first.

The members of the Fact group obtained significantly higher scores in the fact section than in either generalizations or relationships.

The results of the examination of the Relationship group's performance in mathematics are shown in Table CIV. In this class, the mean fact score was higher than either the mean relationship score, or the mean generalization score. In addition, the relationship score was significantly higher than than in generalization.

TABLE CIV

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Fact and Relationship[b]	1.67	0.754	1.012
Fact and Generalization	2.67	0.754	1.012
Relationship and Generalization	1.00	0.754	1.012

[a] Difference must exceed Table Value to be significant at .05 level.
[b] Difference favors section named first.

As may be observed in Table CV, analysis of the scores made by the Generalization group followed the same pattern as that of the Relationship group.

TABLE CV

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION GROUP SUBSCORES ON THE PRE-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Fact and Relationship[b]	1.92	1.249	1.697
Fact and Generalization	3.33	1.249	1.697
Relationship and Generalization	1.41	1.249	1.697

[a] Difference must exceed Table Value to be significant at the .05 level.
[b] Difference favors section named first.

The examination of the scores made on the subsections of the mathematics test seems to indicate that the more meaningful methods produce greater flexibility in performance. The Generalization group obtained higher scores in what may be termed the less meaningful outcomes, namely relationships and facts. The Relationship group, following the same pattern, made high scores on facts, also. The Fact group, on the other hand, showed no tendency to make high scores in areas in which it had not received training. In other words, training in more meaningful methods of study does not appear to produce a set pattern for a specific type of learning outcome but permits the individual to master outcomes associated with less meaningful methods as well.

In general, the analysis of the results of the test in mathematics indicated that the effects of training in a more meaningful method of study tended to be transferred to a greater extent from social studies to mathematics than did the effects of training in a less meaningful method. In addition, it was found that in the examination of the results of later test performance in this group, all pre-test scores must be held constant, except in the case of the analysis of sub-test performance within the Control group.

Science

Means and standard deviations for the distribution of scores in science are presented in Table CVI.

Analysis of variance of the total scores in science resulted in an F-ratio of 3.81, significant at the .05 level. This indicates variability in performance on the part of the classes in this group, and, consequently, pre-test scores will have to be held constant in

TABLE CVI

MEANS AND STANDARD DEVIATIONS FOR THE PRE-TEST IN SCIENCE, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	20	14.15	3.44	4.45	1.50	4.85	1.35	4.85	1.53
Relationship	14	14.71	3.12	4.64	1.45	5.07	1.27	5.00	1.75
Generalization	21	17.14	3.49	5.33	1.53	5.95	1.66	5.86	1.32
Control	19	13.32	4.81	4.26	2.16	4.47	2.12	4.58	1.87

later analyses. To determine the extent to which the effects of training were transferred from mathematics to science by the members of this group, covariance was undertaken with Pre-test I scores held constant. The F-ratio found in this instance was not significant. Differences noted in analysis of variance were due to initial differences in ability to learn facts, relationships and generalizations by the methods employed in this study. The training periods evidently were not sufficient to produce significantly different performance among the classes when the subject matter was changed from mathematics to science.

Analysis of variance and covariance failed to reveal significant differences in mean scores in the fact subsection of the test. The same result was obtained when scores in the generalization section were examined. In this instance, non-linearity of regression was found, and therefore only analysis of variance could be employed. Unlike the results found with the Social Studies - Mathematics group, where superior transfer was made by the Generalization group, the effects of training

in mathematics did not produce differences in performance on the fact and generalization sections of the science test. Since no significant differences were found, later analyses may be undertaken without controlling pre-test scores in these areas.

Significant differences in mean scores were obtained through the analysis of variance of results on the relationship section of the science test. Pre-test scores in this area must, therefore, be controlled during the treatment of later test results. A summary of the t-tests employed in comparing pairs of means is presented in Table CVII.

TABLE CVII

MEAN DIFFERENCE TESTS FOR THE RELATIONSHIP SUBSCORES ON THE PRE-TEST IN SCIENCE, STAGE TWO

	Mean Difference	t	Significance
Generalization and Fact[a]	1.10	2.15	$.01 < p < .05$
Generalization and Relationship	0.88	1.52	$.1 < p < .2$
Generalization and Control	1.48	2.80	$p < .01$
Relationship and Fact	0.22	0.38	$.7 < p < .8$
Relationship and Control	0.60	1.04	$.2 < p < .3$
Fact and Control	0.38	0.72	$.4 < p < .5$

[a] Difference favors group named first.

The Generalization group made significantly higher scores than both the Fact and the Control groups in this section of the test. These findings are in keeping with those noted in the analyses of the mathematics test, namely, that the effects of training in a meaningful method of study tend to be transferred to a greater extent in the area of relationships.

No significant differences were noted in the sub-test performance of any of the classes in this subject matter group. Training in a particular method of study in mathematics apparently was not sufficient to produce differential performance within any class in the science test. Pre-test scores, then,will not have to be held constant, in the later analysis of the sub-test performance within any of the classes of this group.

On the whole, analysis of the Pre-test II scores in science did not reveal conclusive evidence of the transfer of the effects of training in any of the methods employed in this investigation. The only significant difference found was in the relationship section of the test, the results favoring the Generalization group over the Control and Fact groups. In subsequent analyses, the relationship sub-scores are the only ones in science that must be controlled by covariance methods.

Social Studies

Table CVIII contains a summary of means and standard deviations for scores of the Science - Social Studies group in social studies.

TABLE CVIII

MEANS AND STANDARD DEVIATION FOR THE PRE-TEST IN SOCIAL STUDIES,STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	10.57	2.80	3.48	1.25	3.43	1.36	3.67	1.39
Relationship	19	13.37	3.94	4.26	1.59	4.53	1.74	4.58	1.87
Generalization	19	14.32	3.44	3.95	1.22	5.21	1.69	5.16	1.50
Control	15	11.53	3.70	3.53	1.46	3.53	1.77	4.47	1.69

Analysis of covariance with mental ages controlled produced a significant F-ratio, indicating that total scores should be controlled in later analyses. In investigating transfer, Pre-test I scores, in addition to mental age scores, were held constant. On this occasion no significant differences were found in mean total scores. The effects of training in science were not sufficient to produce differential performance on the social studies test.

The analysis of the three subsections of the test, fact, relationship and generalization, did not reveal significant mean differences among the classes of this group. Training in science did not produce differential performance in the social studies pre-test. In the subsequent analysis of the subsections of tests involving the Science - Social Studies group, pre-test scores will not have to be controlled.

On the examination of the sub-test scores made by the members of each methods group, no significant differences were found except in the scores of the Generalization group. After adjustment for differences in Pre-test I, means in this group were investigated using the t-tests, the results being summarized in Table CIX. The adjusted means

TABLE CIX

MEAN DIFFERENCE TESTS FOR THE GENERALIZATION GROUP SUBSCORES ON THE PRE-TEST IN SOCIAL STUDIES, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Generalization and Fact[b]	1.44	0.769	1.032
Generalization and Relationship	1.33	0.769	1.032
Relationship and Fact	0.11	0.769	1.032

[a] Difference must exceed Table Value to be significant at the .05 level.
[b] Difference favors section named first.

were found to be: fact, 3.85; relationship, 5.18; generalization, 5.29. Both the relationship and generalization scores were significantly superior to that in the fact section. These findings suggest that training in the method of generalization results in high performance in the learning of relationships, as well as in the learning of generalizations, but that factual materials are not mastered to the same degree. On the basis of these analyses, only the pre-test scores of the Generalization group need be held constant in later investigations of subscores within each of the classes.

The examination of the results of the social studies test revealed that pre-test scores must be controlled during the subsequent analysis of total scores and subsections of the Generalization group. No other significant differences were found. Apart from variation in the subscores of the Generalization group, no indication was found of training in one method of study producing greater transfer from science to social studies than any other method used in this experiment.

Summary

Analysis of mental ages for classes within each of the subject matter groups revealed that this variable should be controlled in subsequent treatment of data in the Science - Social Studies group. The classes in the Mathematics - Science group and the Social Studies - Mathematics groups did not differ in mean mental ages.

Pre-test II scores in mathematics must be held constant in later investigations involving total scores, fact subscores, relationship subscores, Fact group subscores, Relationship group subscores, and

Generalization group subscores.

In science, the only pre-test scores that must be controlled are total scores and those made in the relationship subsection.

The analyses of subsequent tests in social studies require the control of pre-test total scores and those made by the members of the Generalization group on the subsections of the test.

Analysis of performance on the pre-test in mathematics indicated that the effects of a more meaningful method of study, namely, the study of generalizations, tended to be transferred from social studies to mathematics to a greater extent than did the effects of less meaningful methods of study. In science, the treatment of the scores on the relationship section of the test gave support to this finding. Other areas of the science test, however, revealed no significant differences, as did the analysis of the social studies test.

From the results of these investigations it is not possible to draw a general conclusion concerning the transfer from one subject matter area to another of the effects of training in the study of material for facts, relationships and generalizations.

The analysis of the subsection scores in the three experimental classes in the mathematics test indicated that training in the more meaningful method of study tended to produce high performance in all learning outcomes, while training in a less meaningful method tended to be more specific. Some confirmation of this was found in the Generalization group on the social studies test, where higher scores were made on both generalizations and relationships than on facts, although training emphasized generalizations only. In science, on the other hand, no significant differences were noted. Evidence again does not permit the formation

of a general conclusion.

CHAPTER XII

ANALYSIS OF GAINS FROM PRE-TEST TO POST-TEST IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE TWO

After the experimental classes had completed the training periods in their second subject-matter area, a post-test was administered to all classes. As in Stage One, pre-test scores were subtracted from post-test scores to obtain a distribution of gains made during the period of training. Analysis of these distributions was undertaken to determine the effects of practice with a particular method of study on the learning of facts, relationships and generalizations.

As in the other chapters, the performance of each subject matter group is discussed separately, and in the order: mathematics, science and social studies.

Mathematics

Means and standard deviations for the distributions of gains in mathematics are presented in Table CX.

TABLE CX

MEANS AND STANDARD DEVIATIONS FOR THE DISTRIBUTION OF GAINS FROM PRE-TEST TO POST-TEST IN MATHEMATICS, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	0.38	2.73	-0.81	1.66	1.05	1.63	0.14	2.01
Relationship	18	2.61	2.79	-0.72	1.45	2.00	2.00	1.33	1.53
Generalization	12	0.42	3.42	-1.25	1.60	0.92	2.23	0.75	1.82
Control	21	2.57	3.97	0.19	1.63	1.52	1.78	0.86	2.20

Negative scores in this table indicate that the post-test score was lower than the pre-test score, that is, there was a loss in score over the training period.

An examination of the gains made in total score was carried out by means of analysis of covariance, with pre-test results held constant. A significant F-ratio indicated that there were differences in mean total gains. Means were adjusted for variations in pre-test performance with the following results: Fact, -0.22; Relationship, 2.57; Generalization, 1.68; Control, 2.87. Pairs of adjusted means were compared by t-tests, as shown in Table CXI.

TABLE CXI

MEAN DIFFERENCE TESTS FOR GAINS IN TOTAL SCORE FROM PRE-TEST TO POST-TEST IN MATHEMATICS, STAGE TWO

	Adjusted Mean Differences	t	Significance
Control and Fact[a]	3.09	3.355	$p < .01$
Control and Relationship	0.30	0.315	$.7 < p < .8$
Control and Generalization	1.19	1.106	$.2 < p < .1$
Relationship and Fact	2.79	2.96	$p < .01$
Relationship and Generalization	0.89	0.77	$.3 < p < .4$
Generalization and Fact	1.90	1.67	$.05 < p < .1$

[a] Difference favors group named first.

Both the Relationship and the Control groups made significantly greater gains in mathematics than the Fact group. The difference between the Fact group and the Generalization group favored the latter but did not reach the .05 level.

The comparison of Relationship and Fact gains indicates an advantage in learning by the more meaningful of the two methods employed with these groups. This is given some measure of support, in addition, by the performance of the Generalization group. The improved performance on the part of the Control group must again be attributed to experience within their regular classroom program.

The analysis of the fact, relationship and generalization subsections of the test revealed no significant differences in mean gains. The four periods of training in mathematics failed to produce superior mean gains favoring any of the methods of study employed in this experiment.

Analysis of covariance, with pre-test results held constant, was used to examine the gains in fact, relationship and generalization scores made by the members of the Fact and Generalization groups. In both groups, no significant differences were noted. Within the bounds of chance, gains from pre-test to post-test, made by these groups in the subsections of the test, were equal.

The Relationship group, on the other hand, showed variation in sub-test gains. Analysis of covariance, with pre-test results controlled, produce an F-ratio of 8.70, significant beyond the .01 level. Adjustment for differences in pre-test scores produced the following means: fact, 0.85; relationship, 1.75; generalization, -0.01. The t-tests were used to determine specific mean differences are summarized in Table CXII.

TABLE CXII

MEAN DIFFERENCE TESTS FOR GAINS IN RELATIONSHIP GROUP SUBSCORES FROM PRE-TEST TO POST-TEST IN MATHEMATICS, STAGE TWO

	Adjusted Mean Differences	t	Significance
Relationship and Fact[a]	0.90	1.883	$.05 < p < .1$
Relationship and Generalization	1.76	3.801	$p < .01$
Fact and Generalization	0.86	1.629	$.1 < p < .2$

[a] Differences favor section named first.

The Relationship group made significantly greater gains in relationships than it did in generalizations. The difference between the gains in relationships and facts favored the former but failed to reach the .05 level. The Relationship group also showed a non-significant difference favoring the fact gain over the generalization gain. Within this section of the test there appears to be a trend suggesting that the gains in facts as well as relationships were superior to the gains in generalizations. This is in keeping with earlier evidence indicating that training in a more meaningful method of study produces gains in outcomes associated with less meaningful methods as well as gains in the area of training.

The Control group also showed variable performance on the subsections of the mathematics test. In this instance, as may be observed from Table CXIII, the gains in relationships were greater than the gains in fact. No other differences were significant. The differential performance within the Control group likely is the result of experiences in learning in the regular classroom. The past

experience of this class evidently predisposed it toward the learning of relationships rather than facts or generalizations.

TABLE CXIII

MEAN DIFFERENCE TESTS FOR GAINS IN CONTROL GROUP SUBSCORES FROM PRE-TEST TO POST-TEST IN MATHEMATICS, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Relationship and Generalization[b]	0.76	1.029	1.376
Relationship and Fact	1.33	1.029	1.376
Generalization and Fact	0.67	1.029	1.376

[a] Difference must exceed Table value to be significant at the .05 level.
[b] Difference favors section named first.

The analysis of the distribution of gains from Pre-test II to Post-test II revealed that, in mean total gain, the Relationship and Control groups were superior to the Fact group. The score of the Generalization group also exceeded that of the Fact group, but the difference failed to reach the .05 level of significance. The only other evidence of differential performance came in the subsection gains within the Relationship and Control groups. In the former, significantly greater gains were made in relationships than in generalizations, while in the latter, greater gains were found in relationships than in facts. Although on the basis of total gains, training in relationships appears to produce greater gains, little supporting evidence was obtained from other analyses in mathematics.

Science

The distributions of gains from Pre-test II to Post-test II in

science produced the means and standard deviations summarized in Table CXIV.

TABLE CXIV

MEANS AND STANDARD DEVIATIONS FOR THE DISTRIBUTION OF GAINS FROM PRE-TEST TO POST-TEST IN SCIENCE, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	20	-1.60	3.81	-1.15	1.95	-0.65	2.21	0.20	2.19
Relationship	14	-0.79	3.77	-0.64	2.24	0.07	1.69	-0.21	1.57
Generalization	21	-2.05	2.60	-1.29	1.45	-0.62	1.75	-0.14	1.24
Control	19	-1.47	3.06	-0.47	2.37	-0.95	1.68	-0.05	2.22

Analysis was undertaken to determine mean differences in total gains, in gains in facts, relationships and generalizations, and in gains in the three subsections within each class. In all but the area of relationships, investigation revealed no significant differences. On the relationship subsection, variation in pre-test performance required control of this factor in the analyses. Although the test for homogeneity of regression coefficients was not confirmed, the F-ratio being significant at the .05, but not the .01 level, it was decided to continue analysis of covariance, since other necessary assumptions had been met. This, it was felt, would yield some indication of the effect of pre-test performance that otherwise would require subjective judgment. Adjusting for differences in pre-test scores produced the following means: Fact, -0.83; Relationship, 0.04; Generalization, -0.05; Control, -1.38. Table CXV reveals that both the

TABLE CXV

MEAN DIFFERENCE TESTS FOR GAINS IN RELATIONSHIP SUBSCORES FROM PRE-TEST TO POST-TEST IN SCIENCE, STAGE TWO

	Adjusted Mean Differences	t	Significance
Relationship and Fact[a]	0.87	1.67	$.05 < p < .1$
Relationship and Generalization	0.09	0.17	$.8 < p < .9$
Relationship and Control	1.42	2.67	$p < .01$
Generalization and Fact	0.78	1.62	$.1 < p < .2$
Generalization and Control	1.33	2.78	$p < .01$
Fact and Control	0.55	1.14	$.2 < p < .3$

[a] Difference favors group named first.

Relationship and Generalization groups were superior to the Control group. There is also an indication of higher scores on the parts of these groups when compared with the Fact group, but this failed to reach the .05 level of significance.

It would seem that special training in studying material to determine the significant relationships or generalizations within it produced higher relationship scores than did the usual classroom experience of the Control group. The superiority of these methods over the study of material for facts is suggested, but not clearly established. The four training periods failed to produce differential gains in other areas of the distribution.

Social Studies

Means and standard deviations for the distribution of gains in social

studies from Pre-test II to Post-test II are summarized in Table CXVI.

TABLE CXVI

MEANS AND STANDARD DEVIATIONS FOR THE DISTRIBUTION OF GAINS FROM PRE-TEST TO POST-TEST IN SOCIAL STUDIES, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	-0.81	3.40	-0.33	1.85	-0.14	1.53	-0.33	1.82
Relationship	19	-0.89	3.74	0.00	2.33	-0.58	1.30	-0.32	1.77
Generalization	19	-1.42	3.32	0.32	1.70	-1.05	1.51	-0.68	1.78
Control	15	-2.67	4.64	-0.80	1.86	-0.73	2.25	-1.13	1.92

The analysis of mean gains in social studies followed the pattern obtained in science in that, again, no significant differences were found. The training periods in social studies were insufficient to produce variation in gains from the pre-test to the post-test.

Summary

The analysis of gains in mathematics, science and social studies produced few positive results. The only instances of significant differences in total test performance were found in mathematics, where the Relationship group and the Control group made significantly greater gains than the Fact group. There was a difference favoring the Generalization group over the Fact group, but this failed to reach the .05 level. On this test, also, within the Relationship group, significantly greater gains were made in relationships than in generalizations. Al-

though other differences failed to reach the .05 level of significance, it appeared that gains were made in order of increasing magnitude in the areas of relationship, fact, generalization.

In the science test, greater gains were made in the relationship section by the Generalization and the Relationship groups than by the Control group. While other differences failed to reach the .05 level, the Generalization and Relationship groups both appeared to make greater gains than the Fact group.

In general, the analysis of gains made from pre-test to post-test in the second stage of the experiment did not yield clear-cut evidence of the superiority of training in any of the methods of study employed in the investigation.

CHAPTER XIII

TRANSFER IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE TWO

Twenty-one days after the administration of the post-test, each group was given another test, similar in structure to both the pre-test and the post-test, and equated in difficulty with them. The purpose of this test was to determine the extent to which the effects of training in the study of material for facts, relationships and generalizations were transferred to a new situation in the same subject-matter area.

Transfer test results were examined using analysis of covariance (with pre-test scores and mental age controlled where necessary) and analysis of variance. Results will be reported for each subject-matter separately, and in the usual pattern of mathematics, science and social studies.

Mathematics

Means and standard deviations for the transfer test in mathematics are presented in Table CXVII.

Analysis of covariance, with Pre-Test II held constant, yielded an F-ratio of 7.70 which is significant beyond the .01 level. The means for each class, adjusted for pre-test differences, were as follows: Fact, 10.35; Relationship, 11.76; Generalization, 10.54; Control, 14.21. Mean differences were examined by t-tests, which are summarized in Table CXVIII.

TABLE CXVII

MEANS AND STANDARD DEVIATIONS FOR THE TRANSFER TEST IN MATHEMATICS, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	9.62	2.64	2.90	1.51	3.19	1.40	3.52	1.60
Relationship	18	11.72	4.52	4.33	1.41	3.61	1.65	3.78	2.10
Generalization	12	12.08	2.68	3.83	1.53	4.00	1.35	4.25	0.97
Control	21	14.57	3.26	5.14	1.49	5.28	1.73	4.14	1.43

TABLE CXVIII

MEAN DIFFERENCE TESTS FOR TOTAL SCORES ON THE TRANSFER TEST IN MATHEMATICS, STAGE TWO

	Adjusted Mean Differences	t	Significance
Control and Fact[a]	3.86	4.275	$p < .01$
Control and Relationship	2.45	2.623	$.01 < p < .05$
Control and Generalization	3.67	3.489	$p < .01$
Relationship and Fact	1.41	1.539	$.1 < p < .2$
Relationship and Generalization	1.22	1.077	$.2 < p < .3$
Generalization and Fact	0.19	0.170	$p > .9$

[a] Difference favors group named first

The Control group made significantly higher scores on this test than any of the experimental groups. Experiences in the regular classroom appear to have had greater effect on test performance than the more restricted approach of the experimental methods. In addition, having had fewer demands made of them during the experiment, the Control group could conceivably feel more highly motivated toward the transfer test. This motivation may have resulted in their higher scores. Within the experimental group, the Relationship class made higher scores than both the Generalization and Fact classes, although the differences failed to reach the .05 level of significance.

Analysis of covariance with pre-test scores controlled revealed significant differences in performance on the fact section of the transfer test. The adjusted means for the group were as follows: Fact, 3.14; Relationship, 4.38; Generalization, 3.24; and Control, 5.20.

Mean difference tests, presented in Table CXIX, again revealed the superiority of the Control group. In this instance, however, the Relationship group was also superior to the Fact and Generalization groups. Training in reading a selection in mathematics to determine the significant relationships in it appears to produce superior performance on subsequent testing than does training in facts or generalizations.

A significant F-ratio was obtained when the scores on the relationship subsection of the transfer test in mathematics were subjected to analysis of covariance. After adjustment for differences in pretest scores, means were as follows: Fact, 3.40; Relationship, 3.68;

TABLE CXIX

MEAN DIFFERENCE TESTS FOR FACT SUBSCORES ON THE TRANSFER TEST IN MATHEMATICS, STAGE TWO

	Adjusted Mean Differences	t	Significance
Control and Fact[a]	2.06	4.870	$p < .01$
Control and Relationship	0.82	1.872	$.05 < p < .1$
Control and Generalization	1.96	3.750	$p < .01$
Relationship and Fact	1.24	2.818	$p < .01$
Relationship and Generalization	1.14	2.127	$.01 < p < .05$
Generalization and Fact	0.10	0.186	$.8 < p < .9$

[a]Difference favors group named first

TABLE CXX

MEAN DIFFERENCE TESTS FOR RELATIONSHIP SUBSCORES ON THE TRANSFER TEST IN MATHEMATICS, STAGE TWO

	Adjusted Mean Differences	t	Significance
Control and Fact[a]	1.77	3.598	$p < .01$
Control and Relationship	1.49	2.998	$p < .01$
Control and Generalization	1.45	2.608	$.01 < p < .05$
Generalization and Fact	0.32	0.539	$.5 < p < .6$
Generalization and Relationship	0.04	0.068	$p > .9$
Relationship and Fact	0.28	0.566	$.5 < p < .6$

[a]Difference favors group named first

Generalization, 3.72; Control, 5.17. As may be observed in Table CXX, in this section of the test the Control group maintained its position of superiority over the experimental groups. No other significant differences were obtained.

The variances of the classes on the generalization section of the test were found to be heterogeneous and, as a result, the Cochran and Cox technique was used to examine mean difference. No cases were found in which the means differed significantly. Periods of training failed to produce differential performance on this section of the transfer test.

Analysis revealed that the scores made on the subsections of the transfer test by the members of the Control group differed significantly. The results of t-tests used to compare means are included in Table CXXI.

TABLE CXXI

MEAN DIFFERENCE TESTS FOR CONTROL GROUP
SUBSCORES ON THE TRANSFER TEST
IN MATHEMATICS, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Relationship and Fact[b]	0.14	0.855	1.14
Relationship and Generalization	1.14	0.855	1.14
Fact and Generalization	1.00	0.855	1.14

[a] Difference must exceed Table value to be significant at the .05 level

[b] Difference favors section named first

Significantly higher scores were made on both the relationship and fact sections of the test than on the generalization section. The instruction received in the regular classroom appears to produce higher performance in facts and relationships than in generalizations, as measured by this test.

Since regression was found to be non-linear, analysis of variance was used to examine the mean scores made by the Fact group on the subsections of the transfer test. In this instance, no significant differences were obtained. In an effort to ascertain the influence of differential pre-test performance, where this could not be controlled through covariance, mean difference tests were undertaken to determine the significance of the difference between differences in scores made on the two tests. This, in effect, tests the significance of the gains made from pre-test to transfer test. The results of these tests are presented in Table CXXII. On the pre-test the fact score was found to be significantly greater than both the relationship and generalization scores. To be non-significant on the transfer test gains in both these areas would have to be significantly greater than the gain in the fact score. This suggests that the effects of training within the Fact group were transferred to a greater extent in relationships and generalizations, than they were in facts. Since this group received training only in the study of facts, it is possible that experience outside the experimental situation influenced the performance of the group on this section of the test.

With pre-test scores controlled through analyses of covariance, no significant differences were noted in the performance of the members

of the Relationship group on the subsections of the transfer test. The effects of training in the study of material to determine important relationships did not produce variations in performance on the transfer test.

TABLE CXXII

MEAN DIFFERENCE TESTS FOR DIFFERENCES IN THE SCORES OF THE FACT GROUP ON THE PRE-TEST AND THE TRANSFER TEST IN MATHEMATICS, STAGE TWO

	Difference on Pre-Test	Difference on Transfer Test	t	Significance
Fact and Generalization[a]	1.43	-0.62	3.40	$p < .01$
Fact and Relationship	1.76	-0.29	3.74	$p < .01$

[a]Difference favors section named first

Analysis of covariance could not be used to examine the mean scores made by the Generalization group since regression was found to be non-linear. Analysis of variance failed to reveal significant differences in transfer test scores. On the pre-test, it had beennoted that the scores on the fact section were significantly better than the scores on the generalization or relationship sections, and also, that the relationship score was higher than the generalization score. In an attempt to account for the influence of pre-test variation in performance, mean difference tests were again employed to determine the significance of the difference between the differences in pre-test and transfer test scores in the areas of fact, relationship and generalization. The results of this investigation are summarized in Table CXXIII.

TABLE CXXIII

MEAN DIFFERENCE TESTS FOR DIFFERENCES IN SCORES OF THE GENERALIZATION GROUP ON THE PRE-TEST AND THE TRANSFER TEST IN MATHEMATICS, STAGE TWO

	Difference on Pre-test	Difference on Post-test	t	Significance
Fact and Relationship[a]	1.92	-0.17	2.38	$.02 < p < .05$
Fact and Generalization	3.33	-0.42	7.02	$p < .01$
Relationship and Generalization	1.41	-0.25	2.095	$.02 < p < .05$

[a] Difference favors group named first.

The mean difference tests indicate that the members of the Generalization group made significantly greater gains in their generalization and relationship scores than they did in facts. In addition, greater gain was shown in generalizations than in relationships. Although differences in transfer test scores were non-significant, consideration of pre-test performance suggests that the effects of training in the method of generalization influenced generalization and relationship scores to a greater extent than fact scores on the transfer test.

The analysis of the transfer test in mathematics did not reveal variations in performance among the experimental classes, as far as total scores were concerned. The Control group, however, made significantly higher total scores than any other group. The superiority of the Control group was also noted as a result of the analysis of fact scores on the transfer test. On this section of the test the Relationship group also made significantly greater scores than both the Generalization and the Fact groups. An examination of scores on the relationship section of

the test disclosed no significant differences in performance among the experimental classes. Again the Control group made significantly higher scores than any of the other groups. The Cochran and Cox test revealed no significant differences in generalization scores on the transfer test in mathematics. The experiences of the children in both experimental and control classes were insufficient to produce differential performance in this area of the test.

Within the Control group, analysis of variance revealed significantly higher scores on the generalization and relationship sections than on the fact section. There were no significant differences in the performance of the members of the Relationship group on the three subsections of the transfer test. Analysis of variance disclosed no significant differences in subtest scores made by either the Generalization group or the Fact group. In both these instances, however, it was not possible to control pre-test results in which significant differences had been found. To assess the influences of variations in pre-test performance, a test was employed that, in effect, measured the significance of the gains made from pre-test to transfer test. In the Fact group this analysis indicated that to reach non-significance on the transfer test, significantly greater gains were made in the areas of relationships and generalizations than were made in fact. Within the Generalization group, greater gains were shown in generalizations than relationships, and in both of these areas than in facts.

Generally, the analysis of the transfer test in mathematics failed to produce evidence indicating superior transfer effects for any of the methods of study employed in this investigation.

Science

Means and standard deviations for the scores made by the four classes in the transfer test in science are presented in Table CXXIV.

TABLE CXXIV

MEANS AND STANDARD DEVIATIONS FOR THE TRANSFER TEST IN SCIENCE, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	20	13.50	3.63	4.80	1.47	3.45	1.61	5.25	1.80
Relationship	14	13.57	3.26	5.21	1.05	3.14	1.56	5.21	1.42
Generalization	21	17.67	2.82	6.00	1.22	4.86	1.80	6.81	1.33
Control	19	12.16	4.36	3.89	1.24	3.84	2.48	4.42	1.87

Total scores made on this test were examined by means of analysis of covariance, with pre-test scores in mathematics held constant. A significant F-ratio was obtained, indicating variations in performance among the groups. Adjustment for differences in pre-test performance resulted in the following means: Fact, 13.90; Relationship, 13.67; Generalization, 16.46; Control, 13.45. Pairs of adjusted means were then tested to determine specific differences.

As may be observed in Table CXXV, the Generalization group made significantly higher scores on the transfer test than any of the other groups. These were the only significantly different results obtained.

It would appear that, in science, the effects of training in the study of material for generalizations are transferred to a greater extent than are the effects of training in fact and relationships.

TABLE CXXV

MEAN DIFFERENCE TESTS FOR TOTAL SCORES ON THE TRANSFER TEST IN SCIENCE, STAGE TWO

	Adjusted Mean Differences	t	Significance
Generalization and Fact[a]	2.56	2.568	$.01 < p < .05$
Generalization and Relationship	2.79	2.573	$.01 < p < .05$
Generalization and Control	3.01	2.830	$p < .01$
Fact and Relationship	0.23	0.224	$.8 < p < .9$
Fact and Control	0.45	0.472	$.6 < p < .7$
Relationship and Control	0.22	0.210	$.8 < p < .9$

[a] Difference favors group named first

Significant differences in performance on the fact subsection of the test were revealed by analysis of variance. The comparison of pairs of means revealed that all the experimental groups made significantly higher scores than did the Control group. The Generalization group also was significantly superior in performance to the Fact group. The difference between the Relationship and Generalization groups favored the latter and approached, but did not reach, the .05 level. In the area of fact in science, the effects of training in a more meaning-

ful method of study, namely, the generalization method, appear to be transferred to a greater extent than do the effects of less meaningful methods of study. A summary of the results of the mean difference tests is presented in Table CXXVI.

TABLE CXXVI

MEAN DIFFERENCE TESTS FOR FACT SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE TWO

	Mean Differences	t	Significance
Generalization and Fact[a]	1.20	3.046	$p < .01$
Generalization and Relationship	0.79	1.775	$.05 < p < .1$
Generalization and Control	2.11	5.18	$p < .01$
Relationship and Fact	0.41	0.921	$.3 < p < .4$
Relationship and Control	1.32	2.996	$p < .01$
Fact and Control	0.91	2.236	$.01 < p < .05$

[a] Differences favors group named first

Analysis of covariance, with pre-test scores held constant, did not reveal significant differences in relationship scores. The training periods in the three methods of study apparently were not sufficient to produce variations in performance in this area of the transfer test in science.

A significant F-ratio was obtained when the generalization scores were subjected to analysis of variance. To determine specific

differences, the t-test was used, producing the results summarized in Table CXXVII.

TABLE CXXVII

MEAN DIFFERENCE TESTS FOR GENERALIZATION SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE TWO

	Adjusted Mean Differences	t	Significance
Generalization and Fact[a]	1.56	3.089	$p < .01$
Generalization and Relationship	1.60	2.800	$p < .01$
Generalization and Control	2.39	4.579	$p < .01$
Fact and Relationship	0.04	0.070	$p > .9$
Fact and Control	0.83	1.590	$.1 < p < .2$
Relationship and Control	0.79	1.384	$.1 < p < .2$

[a] Difference favors group named first

The t-tests revealed a pattern of significant differences identical with that found on the analysis of the total scores on the transfer test, that is, the Generalization group made higher scores than the Fact, Relationship and Control groups. No other significant differences were obtained in this area. Again it may be observed that the effects of the more meaningful method of study appear to be transferred to the greatest extent.

Variations in the performance of members of the Fact group in the three subsections of the test were revealed through analysis of variance. Mean difference tests, presented in Table CXXVIII, indicate that the Fact

group made significantly higher scores on the generalization and fact sections of the test than on the relationship section. In addition, their scores were significantly better on the generalization section than on the fact. Since the members of this class received training only in the identification of the facts in a selection, with no consideration being given to either relationships or generalizations, it seems unlikely that their relatively superior performance on the generalization subsection of the test could be the result of the experimental procedures. Quite possibly, after twenty-one days they were influenced more by their regular classroom methods than by the restricted methods of the experiment.

TABLE CXXVIII

MEAN DIFFERENCE TESTS FOR FACT GROUPS
SUBSCORES ON THE TRANSFER TEST
IN SCIENCE, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Generalization and Relationship[b]	1.80	0.188	0.252
Generalization and Fact	0.45	0.188	0.252
Fact and Relationship	1.35	0.188	0.252

[a] Difference must exceed Table value to be significant at the .05 level
[b] Difference favors section named first

The members of the Relationship group, as may be noted in Table CXXIX, scored significantly higher on both facts and generalizations than they did on relationships.

TABLE CXXIX

MEAN DIFFERENCE TESTS FOR RELATIONSHIP GROUP SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Generalization and Relationship[b]	2.07	0.785	1.062
Generalization and Fact	0.00	0.785	1.062
Fact and Relationship	2.07	0.785	1.062

[a]Difference must exceed Table value to be significant at the .05 level
[b]Difference favors section named first

The higher scores in facts could be the results of training in studying materials by a method stressing the relationships between facts. Since, in the training periods for this group, no attempt was made to develop generalizations as defined in this study, it is difficult to attribute superior scores in this area to the effects of the training period. It may be that the differentiation between relationships and generalizations was not clearly made in this section of the experiment.

Analysis of variance yielded a significant F-ratio with the subscores of the Generalization group. The mean difference tests in this area are summarized in Table CXXX.

Differences in this instance followed the same pattern as was found with the Relationship group, in that scores made on the generalization and fact sections were significantly higher than those made on the relationship section. The effects of training in the generalization

method evidently were not transferred in a uniform manner, having less influence on the learning of relationships than on the learning of facts and generalizations.

TABLE CXXX

MEAN DIFFERENCE TESTS FOR GENERALIZATION GROUP SUBSCORES ON THE TRANSFER TEST IN SCIENCE, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Generalization and Relationship[b]	1.95	0.869	1.163
Generalization and Fact	0.81	0.869	1.163
Fact and Relationship	1.14	0.869	1.163

[a] Difference must exceed Table value to be significant at the .05 level

[b] Difference favors section named first

The analysis of subscores made by members of the Control group failed to produce significant differences. Their experiences in the regular classroom did not produce differential performance on the three areas of the transfer test.

The analysis of the transfer test in science revealed greater variation in performance than was found in mathematics, Considering scores made on the test as a whole, the Generalization group was significantly superior to the three other groups, Fact, Relationship and Control. Similar results were obtained on the analysis of the generalization section of the test, while in the area of facts, the Generalization group scored significantly higher than the Fact group, but not the

Relationship group. The latter difference favored the Generalization group although it did not reach the .05 level of significance. Analysis of the relationships scores failed to reveal significant differences in performance.

The analysis of the performance on the subsections of the test, within each experimental group, did not produce decisive results. Significantly higher scores were generally made in facts and generalizations than in relationships. It is quite possible that this pattern reflects the difficulty of the relationship section of the test, rather than variations produced by the different methods of study. Although differences in difficulty indices did not reach the .05 level, Table V in Chapter Five indicates that the relationship section of the test was the most difficult.

Social Studies

Means and standard deviations for the transfer test in social studies are presented in Table CXXXI.

Total scores made by the four classes were examined by analysis of covariance, with mental age and pre-test performance held constant. An F-ratio of 2.05 was obtained which was not significant at the .05 level. This indicated that apparent differences in the raw scores may be explained in terms of variations in average mental ability and familiarity with the methods employed in the study. The training periods in social studies failed to produce real differences in performance on the transfer test.

TABLE CXXXI

MEANS AND STANDARD DEVIATIONS FOR THE TRANSFER TEST IN SOCIAL STUDIES, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	10.38	4.11	3.29	1.23	3.23	1.99	3.86	1.71
Relationship	19	13.16	4.58	4.74	1.94	4.47	1.68	4.47	1.92
Generalization	19	15.32	3.82	4.89	1.76	5.26	1.24	5.16	1.74
Control	15	11.40	2.67	3.80	1.42	4.47	1.51	3.13	0.99

Analysis of covariance of the scores on the fact subsection of the test, with mental age controlled, yielded a significant F-ratio. Adjustment for differences in mental age produced the following means: Fact, 3.43; Relationship, 4.84; Generalization, 4.45; Control, 4.03. Table CXXXII contains a summary of the mean difference tests undertaken to determine specific instances of differential test performance. Both the Relationship group and the Generalization group were superior to the Fact group on this section of the test. No other differences were significant. The effects of training in the more meaningful methods of study, in this case, were transferred to a greater extent than were the effects of the less meaningful method.

Examination of scores on the relationship subsection of the transfer test in social studies also revealed significant differences in

TABLE CXXXII

MEAN DIFFERENCE TESTS FOR FACT SUBSCORES ON THE TRANSFER TEST IN SOCIAL STUDIES, STAGE TWO

	Adjusted Mean Differences	t	Significance
Relationship and Fact[a]	1.41	3.006	$p < .01$
Relationship and Generalization	0.39	0.783	$.4 < p < .5$
Relationship and Control	0.51	0.994	$.3 < p < .4$
Generalization and Fact	1.02	2.065	$.01 < p < .05$
Generalization and Control	0.42	0.775	$.4 < p < .5$
Control and Fact	0.60	1.200	$.2 < p < .3$

[a] Difference favors group named first

performance. As before, analysis of covariance was used, with mental age held constant. The means for the classes, following adjustment for differences in mental age, were: Fact, 3.36; Relationship, 4.56; Generalization, 4.87; Control, 4.68. Pairs of adjusted means were compared using the t-test, the results of which are presented in Table CXXXIII.

As in the previous analysis, the Relationship and Generalization groups obtained significantly higher scores than the Fact group. On this occasion, the Control group was significantly better than the Fact group as well. No other significant differences were found. Again, the results indicate the superiority of the more meaningful methods of study,

the methods of generalization and relationship, over the less meaningful method, the study of facts.

TABLE CXXXIII

MEAN DIFFERENCE TESTS FOR RELATIONSHIP SUBSCORES ON THE TRANSFER TEST IN SOCIAL STUDIES, STAGE TWO

	Adjusted Mean Differences	t	Significance
Generalization and Fact[a]	1.51	2.915	$p < .01$
Generalization and Relationship	0.31	0.594	$.5 < p < .6$
Generalization and Control	0.19	0.335	$.7 < p < .8$
Control and Fact	1.32	2.519	$.01 < p < .05$
Control and Relationship	0.12	0.223	$.8 < p < .9$
Relationship and Fact	1.20	2.439	$.01 < p < .05$

[a] Difference favors group named first

The assumption of homogeneity of variance could not be met in the distributions of scores on the generalization section of the test, indicating that analysis of variance or covariance should not be undertaken. Inspection of Table CXXIX revealed that heterogeneity was due to the small variance of the Control group. On the elimination of the Control group, homogeneity was confirmed and the scores of the experimental groups, alone, were subjected to analysis of covariance with mental age held constant. This treatment revealed no significant differences among the experimental groups on this section of the test.

Apparently the effects of training were not sufficient to produce variations in performance on the generalization questions of the transfer test in social studies. The performance of the Control group was investigated by the use of the Cochran and Cox technique. Both the Fact group and the Generalization group obtained significantly higher scores than the Control group, according to this analysis. Mental age was not held constant, however, and the mean mental age for the Generalization group was higher than that of the Control group. Undoubtedly, the difference in mental age would reduce the mean difference, but it seems unlikely that the difference would become non-significant. The results of this analysis are summarized in Table CXXXIV.

TABLE CXXXIV

MEAN DIFFERENCE TESTS FOR CONTROL GROUP SCORES ON THE GENERALIZATION SUBSECTION OF THE TRANSFER TEST IN SOCIAL STUDIES, STAGE TWO

	t'_{05}	t'_{01}	t
Generalization and Control[a]	2.113	2.906	4.160
Relationship and Control	2.112	2.902	2.552
Fact and Control	2.106	2.884	1.570

[a] Difference favors group named first

Analysis of the scores of each of the experimental classes failed to reveal any instances of significant differences. Within each class the effects of training in social studies appeared to be transferred uniformly.

Analysis of variance of the subscores obtained by the Control group yielded a significant F-ratio. Results of the mean difference tests are shown in Table CXXXV.

TABLE CXXXV

MEAN DIFFERENCE TESTS FOR CONTROL GROUP
SUBSCORES ON THE TRANSFER TEST
IN SOCIAL STUDIES, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Relationship and Generalization[b]	1.34	0.903	1.218
Relationship and Fact	0.67	0.903	1.218
Fact and Generalization	0.67	0.903	1.218

[a] Difference must exceed Table value to be significant at the .05 level
[b] Difference favors section name first

The members of the Control group made significantly higher scores on the relationships subsection than on facts or generalizations. Differential performance by members of this group reflect their experience in the regular classroom and are not the result of special training in this experiment.

The analysis of the results of the transfer test in social studies produced some evidence that supports the idea that the effects of training in a more meaningful method of study are transferred to a greater degree than those of a less meaningful method. Although differences in total scores were not significant at the .05 level, both the Generalization and the Relationship groups made higher scores than the Fact group.

The superiority of the former groups reached significance on both the fact and relationship sections of the test. Again, in the area of generalizations, although the differences were not significant, the Relationship and Generalization groups ranked higher than the Fact group, according to raw scores.

Training in the three methods of study did not produce differential performance on the subsections of the transfer test on the part of the members within any of the groups.

Summary

The only instance of significant differences in total test performance occurred in science, where the Generalization group was superior to all the other groups. In both mathematics and science, however, differences in scores favored the more meaningful methods, although the .05 level of significance was not reached.

On the fact section of the transfer tests, the Generalization group made a significantly higher score than the Fact group, in science and social studies. In addition, in social studies, the Relationship group made a significantly higher score than the Fact group. The Relationship group in mathematics was superior to both the Generalization and the Fact groups on the transfer test.

On the social studies test, the Generalization and Relationship groups made significantly higher scores than the members of the Fact group in the area of relationships. There were no significant differences in this area on either the mathematics or the science test, although in both instances the raw scores for the Generalization group were higher than that for the Fact or Relationship groups.

In the generalization section of the transfer test in science the Generalization group was found to have a significantly higher score than both the Fact and Relationship groups. A similar pattern was observed in mathematics and social studies, although in these instances differences failed to reach the .05 level of significance.

Analysis of the fact, relationship and generalization scores within each of the groups on the transfer test failed to reveal a pattern for the effects of any of the training periods.

On the whole, the results of the comparison of the performance of the experimental classes on the transfer tests in mathematics, science and social studies support the hypothesis that the effects of more meaningful methods of study are transferred to a greater extent than the effects of a less meaningful method.

CHAPTER XIV

RETENTION IN MATHEMATICS, SCIENCE AND SOCIAL STUDIES, STAGE TWO

In an attempt to determine the effects of a passage of time on the retention of material learned after training in one of the three methods of study employed in this investigation, the multiple-choice test given each class as part of the post-test was administered again after a twenty-one day interval. The results of this retention test were subtracted from those of the post-test to obtain a distribution of losses. The analyses of these distributions are presented in the present chapter. As before, the order of presentation is mathematics, science and social studies.

Mathematics

Means and standard deviations for the distribution of retention scores are presented in Table CXXXVI. It should be noted that, since

TABLE CXXXVI

MEANS AND STANDARD DEVIATIONS FOR RETENTION SCORES IN MATHEMATICS, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	0.57	2.71	0.52	1.40	-0.05	1.91	0.10	1.84
Relationship	18	1.22	3.61	0.67	1.61	0.06	1.66	0.50	2.01
Generalization	12	1.17	2.59	1.17	2.04	-0.25	1.49	0.25	1.29
Control	21	1.24	3.36	0.71	1.42	-0.43	1.78	0.95	1.53

these means represent losses, the lower score indicates superior retention.

Analysis of covariance with pre-test performance held constant was employed to investigate mean total scores in retention. The resulting F-ratio was not significant, indicating that there was no variation among the groups, beyond the bounds of chance. Training in different methods of study did not produce differential performance on the retention test in mathematics.

The analysis of the fact, relationship and generalization subsections of the distribution of retention scores also failed to reveal significant differences among the groups in retention.

Similar results were obtained when the scores in the subsections of the distribution were compared within each of the experimental groups. It appears that, generally, the training received by these groups did not result in variations in retention.

The Control group, on the other hand, exhibited differences in performance. The results of t-tests, employed after analysis of variance revealed a significant F-ratio, are summarized in Table CXXXVII.

TABLE CXXXVII

MEAN DIFFERENCE TESTS FOR THE CONTROL GROUP SUBSCORES IN RETENTION IN MATHEMATICS, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Fact and Relationship[b]	1.143	0.859	1.149
Fact and Generalization	0.238	0.859	1.149
Generalization and Relationship	1.381	0.859	1.149

[a] Difference must exceed Table value to be significant at the .05 level.
[b] Difference favors section named first.

This group, through the influence of regular classroom instruction, tended to retain relationships better than facts and generalizations.

On the whole, it appears that training in the three methods of study employed in this investigation failed to produce differences in retention in mathematics among the groups after a twenty-one day interval.

Science

Table CXXXVIII contains the means and standard deviations for the distribution of retention scores in science.

TABLE CXXXVIII

MEANS AND STANDARD DEVIATIONS FOR RETENTION SCORES IN SCIENCE, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	20	1.25	2.69	0.35	1.90	0.15	1.73	0.75	1.52
Relationship	14	2.00	2.29	0.29	1.94	1.00	1.11	0.71	1.20
Generalization	21	0.90	3.00	-0.19	1.66	0.62	1.43	0.48	1.25
Control	19	1.26	3.36	0.47	1.84	0.21	1.55	0.58	1.61

As on previous occasions, analyses were undertaken with total scores, subsection scores, and with scores made by the members within each group. In science, these investigations revealed no significant differences. The training periods failed to produce differential retention among the groups in science.

Social Studies

Means and standard deviations for retention scores in social studies are summarized in Table CXXXIX.

TABLE CXXXIX

MEANS AND STANDARD DEVIATIONS FOR RETENTION SCORES IN SOCIAL STUDIES, STAGE TWO

Group	N	Total		Subscores					
				Fact		Relation		Generalization	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Fact	21	-0.43	3.47	0.00	1.34	0.29	1.42	-0.71	-0.43
Relationship	19	0.53	2.87	0.63	1.42	0.21	1.96	-0.32	1.60
Generalization	19	1.53	3.13	0.47	1.31	1.05	1.13	0.00	1.97
Control	15	0.53	3.25	0.33	1.29	0.40	1.45	-0.20	2.14

The analyses of the total scores and those of the fact, relationship and generalization sections of the distribution again did not reveal significant differences among the groups.

Investigation of subsection performance within each group also failed to yield significant differences except in the case of the Fact group. The results of the mean difference test, employed after analysis of variance indicated variations in scores, are presented in Table CXL.

The members of this group retained significantly more generalizations than they did relationships. Since this class received instruction only in identifying facts in a selection, the results of this analysis must be considered a reflection of the training received by the members outside the experimental situation.

TABLE CXL

MEAN DIFFERENCE TESTS FOR THE FACT GROUP SUBSCORES IN RETENTION IN SOCIAL STUDIES, STAGE TWO

	Mean Difference	D_{05}[a]	D_{01}
Relationship and Fact[b]	0.29	0.808	1.082
Relationship and Generalization	1.00	0.808	1.082
Fact and Generalization	0.71	0.808	1.082

[a] Difference must exceed Table value to be significant at the .05 level.
[b] Difference favors section named first.

Generally, the results of the analyses of retention scores in social studies followed the pattern of mathematics and science. The training periods failed to produce differential retention on the part of the groups involved in the experiment.

Summary

The analyses of the distributions of retention scores in mathematics, science and social studies, on the whole, failed to reveal significant differences in performance. The training periods and methods employed in this investigation apparently were incapable of producing variation in retention among the groups taking part.

CHAPTER XV

A SUMMARY OF THE FINDINGS OF STAGE TWO IN LEARNING, TRANSFER AND RETENTION

Stage two of the experiment included the tests and training periods associated with the second subject-matter area assigned to each class. Data were treated following the pattern of stage one; that is, analyses were made of the distribution of gains from pre-test to post-test, of performance on the transfer test, and of the distribution of losses from post-test to retention test.

In addition, the scores made on the pre-test for stage two were analysed, with mental age and initial ability in the methods of this experiment controlled where necessary. This investigation revealed the extent to which the effects of training were transferred from one subject matter area to another.

A summary of the results of these analyses are presented in this chapter.

Gains from Pre-Test to Post-Test

Mathematics

The analysis of gains in total score revealed that both the Relationship and the Control groups made significantly greater gains in mathematics than did the Fact group. The difference between the Fact and Generalization groups favored the latter and approached, but did not reach the .05 level of significance. The examination of the fact, relationship and generalization sections of the test did not

reveal significant differences in gains.

Within the Relationship group, significantly greater gains were recorded in relationships than in generalizations. The members of the Control group showed superior gains in relationships than in facts, the difference being significant beyond the .05 level. No significant differences in mathematics were noted in the subsection performance of the Fact and Generalization groups.

Science

In science, the analysis of the distribution of gains revealed significant differences in only one instance, that of the relationship subsection. The Generalization and Relationship groups both made significantly greater gains in science than did the Control group. There is an indication in this area of the superiority of the Generalization and Relationship groups over the Fact group, but differences failed to reach the .05 level of significance.

Social Studies

In social studies, the analysis of mean gains in total score and in the three subsections of the distribution, and the analysis of the performance of members within each group did not reveal any instance where differences were significant.

Summary

Apart from the superiority of the Relationship group over the Fact group in total mean gains in mathematics, no evidence was obtained through the analysis of gains that would indicate the

superiority of any of the methods of study employed in this investigation.

The pattern of non-significance found from the analysis of the subsection scores in mathematics within all classes except those of Relationships and Control, indicates that gains, in general, were made uniformly in the areas of fact, relationship and generalization.

Transfer Within the Same Subject Matter Area

Mathematics

The analysis of the total scores in mathematics revealed that the Control group made significantly higher scores than any of the other groups. The Relationship group also made higher scores than both the Fact and the Generalization groups, but this difference failed to reach the .05 level of significance. The Control group again was superior in the fact subsection of the test, but here the Relationship group also made a significantly higher score than both the Fact and Generalization groups. In the area of relationships the only instances of significant differences favored the Control group over the three experimental groups. There were no significant differences found in the analysis of the generalization section of the test.

Analysis of the performance of the members of the Control group on the subsections of the test disclosed that significantly higher scores were made in both relationships and fact than in generalizations. Within the Fact and Generalization groups the effects of training appeared to be transferred to a greater extent in relationships and generalizations than they were in facts. No significant differences

were noted within the Relationship group.

Science

The Generalization group made a significantly higher total score than any of the other groups in the transfer test in science. On the fact section of the test, all the experimental groups achieved significantly higher scores than did the Control group. In addition, in this section, the Generalization group again was superior to the Fact group. The analysis of the generalization section of the test yielded the same pattern of results as that of the total scores, the Generalization group being significantly better than all the other groups. No significant differences were obtained from the relationship section of the test.

Analysis of the performance of the members of the Fact, Relationship and Generalization groups on the subsections of the test revealed that in each case significantly higher scores were made in facts and generalizations than in relationships. In addition, the members of the Fact group scored significantly higher in generalizations than in facts. No significant differences were obtained from the examination of the subscores within the Control group.

Social Studies

No significant differences were obtained from the analysis of the total scores in social studies. On the fact and relationship sections of the test both the Generalization and the Relationship groups achieved significantly higher scores than the Fact group. Also, in the area of relationships, the Control group was superior to the Fact group,

the difference being significant beyond the .05 level. The examination of scores made in the generalization section of the test revealed significantly better performance on the part of the Fact and Generalization groups than the Control group.

Within the Control group, significantly higher scores were made on the relationship subsection than on facts or generalizations. No significant differences were obtained on the analysis of the subsection performance within each of the other groups.

Summary

In general, the results of the analysis of the transfer test in science support the view that the effects of training in more meaningful methods of study are transferred to a greater extent than the effects of a less meaningful method.

Although there was some variation in performance within the classes, results on the whole were inconclusive. It was not possible to determine the effects of training in a particular method of study on the three outcomes within each class.

Transfer from One Subject Matter Area to Another

Mathematics

The analysis of total score and the scores on the fact sections of Pre-Test II revealed that the Generalization group was significantly better than all the other groups. On the relationship section, the Generalization group made significantly higher scores than the Fact and Relationship groups. The Control group, in this area, was superior

to the Fact group, also. The Fact, Generalization and Control groups all made significantly higher scores on the generalization section of the test than did the Relationship group.

The analysis of the subsection scores within each group revealed variation in performance in all but the Control group. The members of the Fact, Relationship and Generalization groups obtained significantly higher scores in the fact section than in either generalizations or relationships. In addition, the score on the relationship section was significantly higher than that in generalization for both the Relationship and Generalization groups.

Science

The analysis of total scores revealed that there were no significant differences among the groups in science. The fact and generalization sections also did not produce differences in Pre-test II. The Generalization group made significantly higher scores than did the Fact and Control groups on the relationship section of the test. No significant differences were found on the analysis of the subscores made on the science test by the members within any of the groups.

Social Studies

No significant differences were noted in the analysis of total scores on the pre-test in social studies. The examination of the three subsections of the test also failed to reveal instances of significant differences.

The only significant difference found in the analysis of the

subsection performance within each group occurred in the Generalization group. In this case, generalization and relationship scores were significantly higher than fact scores.

Summary

In mathematics, analysis of the distribution of scores on the pre-test appeared to indicate that the effects of training in a more meaningful method of study tended to be transferred from social studies to mathematics to a greater extent than did training in a less meaningful method. Also, within the mathematics test, the analysis of subsection scores within the experimental groups revealed that the effects of training in a more meaningful method of study seemed to result in more flexible performance on the transfer test than do those of a less meaningful method. This was suggested by the fact that in the Generalization and Relationship groups high scores were made in less meaningful outcomes, while the Fact group showed high scores only in the area of instruction. The results of the analyses of the science and social studies tests failed to support the findings in mathematics and consequently a general conclusion cannot be drawn.

Retention

Mathematics

The analyses of the distributions of retention scores in mathematics failed to reveal significant differences except in the subsection performance of the members of the Control group. In this instance, the members retained more relationships than they did facts

and generalizations.

Science

In science, the examination of retention scores failed to disclose any instances of significant differences among the groups or in the subsection scores made by the members within any of the groups.

Social Studies

The examination of total scores and those of the fact, relationship and generalization sections did not reveal significant differences among the groups. The members of the Fact group, however, retained significantly more generalizations than relationships. This was the only instance of which significant differences were obtained on the analysis of subsection performance within the groups in social studies.

Summary

The analysis of the distributions of retention scores on the whole failed to reveal significant differences in performance. Since few instances of variation were noted within any of the groups, it appears that there was uniformity of retention of facts, relationships and generalizations within each of the classes.

Tentative Conclusions

The analysis of the data for the second stage of the experiment permits certain tentative conclusions to be drawn.

1. Apart from the superiority of the Relationship group over the Fact group in mathematics, there was no evidence that training

through one particular method of study produced greater gains in learning than training through any of the other methods employed in this investigation.

2. Gains appeared to be made uniformly in the areas of fact, relationship and generalization with all methods of study used in the experiment.
3. Within the same subject-matter area, the effects of training in more meaningful methods of study, those of relationships and generalizations, appeared to be transferred to a greater extent than the effects of the less meaningful method of study, that of facts.
4. Although there was some variation in the performance of members within each class on the subsections of the transfer test, evidence was inconclusive. The extent to which the transfer of the effects of training influenced results within each group could not be determined.
5. The effect of training in a more meaningful method of study tended to be transferred from social studies to mathematics to a greater extent than did the effects of training in a less meaningful method. The results from other subject matter groups failed to support this finding, however, and consequently a general conclusion cannot be drawn.
6. The analysis of the subsection results within each of the classes on the transfer test in mathematics seemed to indicate that training in the more meaningful method of study produced greater flexibility of performance than did the less meaningful

methods. Again the results in science and social studies did not support this finding, and hence no generalization can be made.

7. There was no indication that training in one method of study produced greater retention of material after an interval of twenty-one days than did training in any of the other methods employed in this investigation.
8. Retention of facts, relationships and generalizations within each of the classes appeared to be uniform for the three methods of study used in the experiment.

CHAPTER XVI

CONCLUSIONS AND IMPLICATIONS FOR FURTHER STUDY

Conclusions

The conclusions presented in this chapter result from a synthesis of the findings of stage one of the experiments which were reported in Chapter Ten and the results of stage two which were summarized in Chapter Fifteen.

1. In the majority of cases, the three methods of study employed in this experiment were equally effective in producing gains in learning as measured by the difference between scores of the pre-test and the post-test. It may be worthy of note, however, that where differences in gains occurred, the more meaningful methods of study were favored over the less meaningful.
2. Within each of the classes involved in this experiment, gains appeared to be made uniformly in the areas of fact, relationship and generalization.
3. Within the same subject-matter area, the effects of training in the more meaningful methods of study, those of generalization and relationship, appeared to be transferred to a greater extent than did the effects of training in a less meaningful method, that of facts.
4. Although there was some variation in the performance of members within each class on the subsection of the transfer

test, evidence on the whole was inconclusive. The extent to which the transfer of the effects of training influenced results within each group could not be determined.

5. The effects of training in a more meaningful method of study tended to be transferred from social studies to mathematics to a greater extent than did the effects of training in a less meaningful method. Results of the investigation of transfer from science to social studies, and from mathematics to science, did not support this finding since, in general, no significant differences were noted.
6. The effects of training in a more meaningful method of study in social studies appeared to produce greater flexibility of performance in mathematics than did the training in a less meaningful method. Again, it appears that these results are specific for the classes in the Social Studies - Mathematics group, since the examination of the other groups failed to produce evidence to support this finding.
7. There was no indication that training in one method of study produced greater retention of material after an interval of twenty-one days than did training in any of the other methods employed in this investigation.
8. In the majority of cases, the retention of facts, relationships and generalizations appeared to be uniform for each of the three methods of study used in this experiment.

Discussion of the Results

As has been noted above, where significant differences were obtained in the analyses, the results generally favored the more meaningful approach to learning. Evidence to this effect was most clear-cut in the area of transfer within the same subject matter field. For the most part, the Generalization group was found to have made significantly higher scores than the Fact group. There were, however, a number of instances in which the Generalization group was superior to the Relationship group, and also a number in which the Relationship group made higher scores than the Fact group. The total picture suggested by these results is that of a gradient of meaningfulness of methods of study beginning with the lowest level, the study of facts, and extending through the study of relationships to the highest level, the study of generalizations.

Subject to corroboration from other investigations, it would appear, then, that pupils should be encouraged to draw conclusions from the material presented in class and to justify conclusions already made in a reading selection. Stress should also be placed on the development of principles and their application. In other words, to be most effective, techniques should be employed in the classroom which emphasize generalizations rather than the mere facts in a selection.

There were few instances of negative results in the experiment, in the sense that a less meaningful method of study produced superior results. There were, however, many areas of investigation

which yielded results that were inconclusive, that is, areas in which no differences were found. This was particularly noticeable in the measurement of retention. In the present study the students were not informed during the initial presentation of the material that they would be tested for retention at a later date. It is possible therefore that learning was undertaken without the intent to retain and that consequently their performance on the retention test was affected.

Although it was found on the transfer test that a more meaningful method of study was advantageous in later learning, this method did not appear to influence retention. It would seem, then, that classroom teachers would be well advised to give emphasis to retention during instruction, rather than to rely solely on a particular method of study. Further investigation, however, is required to clarify this point.

It should be noted, too, that as youngsters mature in a good school situation, there is a natural consolidation of traits, attitudes and habits related to methods of study which causes them to become relatively rigid and resistant to change. These attitudes and habits would have a tendency to blur the effectiveness of the present study. It is difficult to see how this situation could have been avoided, however, since selections from the grade seven course of studies served as the material for the experiment.

In the light of this, it is possible that the training periods employed in this investigation were of insufficient length to overcome behavioral patterns resulting from almost seven years of school attendance.

Consideration must also be given to the fact that, concerning methods, the modern teacher is eclectic, varying techniques to meet the needs of the pupils. As a result of this, the students in the experimental classes would be unaccustomed to the restrictions placed on them during the training periods. Prolonged periods of operation with a single method of study would very likely tend to reduce the motivation of the class as a whole. This might account for the failure of the post-test to produce evidence of gains in learning, while significant results were obtained with the transfer test. The post-test, it may be recalled, was administered immediately following the training periods, but before the transfer test there was an interval in which the experimenter did not meet the classes. This rest period may have resulted in renewed interest on the part of the students when the testing program was resumed, a factor which, in turn, would influence performance.

The position of the Control group in the experiment is worthy of note. It must not be assumed, as is the case in many other investigations, that the Control group was intended to represent the lowest level of attainment in this experiment. Inasmuch as the members of this group were working under usual school conditions with their regular teachers, it was not surprising that in some instances they exceeded the performance of the experimental groups. On the whole, the study appeared to indicate that the grade seven classes of the Control group were operating for the most part at a higher level of meaning than the Fact group, but not at the level of the Generalization group. The fact that in many instances there were no differences

between the experimental groups and the Control group may also be taken as further indication of the stability or set of the students toward methods of study after seven years in school.

Although there were indications that learning with meaning has been incorporated into the modern classroom, the failure of the Control group to achieve as well as the Generalization group would suggest that learning with meaning has not reached its maximum in current educational practice. Possibly greater emphasis should be given to the development of the ability to read for generalizations than is presently the case. Since habits associated with methods of study seemed to be resistant to change by the grade seven level, it would likely be best to initiate this attention to the development of the ability to read for generalizations early in the school program. If, however, changes in methods of study must be made in the later grades, it appears that considerably more extensive training than was employed in the present investigation would be required.

Implications for Further Study

1. Since the conclusions outlined above must be restricted to the classes and grade involved in this investigation, confirmation and clarification of the findings would result from a repetition of the experiment with other groups of classes. Before this was undertaken, consideration should be given to the following suggestions:
    (a) To make the findings more general, an attempt should be made to secure a truly random sample of classes.

(b) The number of cases in each subject matter group should be increased so that greater confidence could be placed in the results of the analysis of the data.

(c) The classes should be matched for mental age, socio-economic status and previous educational experience in order to restrict sources of variation beyond the experimental situation.

(d) The use of tests standardized on Alberta populations would provide more reliable measures and make the conclusions of the study more acceptable.

2. The relationship between the meaningfulness of the method of study employed by students in learning and the degree of retention requires further investigation. Providing the pupil, before the initial learning period, with the information that there will be a retention test might prove to be of value. Conceivably other incentives could be utilized to develop a set for retention.

3. Since the results of this experiment in grade seven differ from those conducted in lower grades, an investigation of the relationship between meaning and learning at an intermediate level, for example, grade four, might be a worthy undertaking. Experimentation involving high school and university classes should also be considered in that such results would permit the formulation of generalizations to cover the entire range of the educational system.

4. The inclusion of subject matter areas other than mathematics, science and social studies would yield a more comprehensive representation of the relationship between meaning and learning in the classroom.

5. If the findings of the present study are corroborated by other investigations, experimentation should be undertaken to determine, within each subject-matter area, the classroom techniques that most effectively emphasize meaning in learning.

6. The examination of the transfer of the effects of training in a particular method of study from one subject matter area to another needs to be extended, since the results of the present study were inconclusive. Outcomes of a more detailed investigation would possibly indicate whether the most worthwhile methods of study would transfer generally or whether instruction would be required in each subject-matter area.

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APPENDIX A

EXAMPLE OF READING SELECTION AND TESTS FOR SOCIAL STUDIES

SOCIAL STUDIES III

THE FIRST PEOPLE

The first Canadians all looked more or less alike. They all had brown skins, brown eyes and black hair, erect and graceful bodies, small hands and feet. They all used stone tools: knife, axe, scraper and point for spear or arrow. The needles and combs used by the women were carved from bone, horn or ivory.

With these poor tools the Indian had to get his food, clothing and shelter. For these he depended chiefly on the animal life of the country. Each tribe hunted the large animal common in its hunting ground: moose in the woodlands, buffalo on the prairies, caribou and seal in the north, besides bear, deer, wolf, rabbit, fish and wildfowl which were found everywhere in Canada. The Iroquois and Hurons grew corn and tobacco. The Ojibways made maple sugar and gathered the wild rice which flourished in their region. Small fruits were plentiful in most parts and upon these the tribes feasted in season. Deerskin was used everywhere for clothing. The women of the coast tribes wove also cloaks of cedar-bark strips for common folks, goat's wool for chiefs, and beautiful ones of bright-colored feathers for great occasions.

Homes were made of whatever materials the hunting grounds supplied. The frames had to be of a kind that could be set up and taken down quickly, so the Indian invented the wig-wam, or teepee, which was used in all parts of Canada. The eastern tribes made wig-wams of poles interlaced at the

top and covered with birch-bark. The Ojibway and the Cree used a round-topped shelter made of willow boughs stuck in the ground at both ends. The western peoples lived in skin covered teepees. The eskimo built a log, or snow house, or sheltered in a tent of skin, according to the season and the work he was doing.

The Hurons and Iroquois did a little farming and so built more permanent homes. Their "long houses" were apartment houses, 50 yards long by 12 wide with a central passage dotted with fires, one to each two families. When a young couple married, the household moved the end wall of the house along and built two or three yards of new side wall to make room for the new family and the new hearth.

The Pacific coast Indians had a steady supply of fish and lived much of their lives in one place, so they built houses of lumber. They were longer and wider than the Iroquois "long houses", framed with cedar posts and beams, and covered with wide cedar planks. They carved the posts of the house and carved and painted totem poles to stand in front of it.

With the materials in his neighborhood, the Indian built also the different kinds of transport he needed. There were trails, but no roads or bridges in Canada before the white man came. In winter the eastern tribes moved their goods about on toboggans. The northern people used dog-sleds, while the prairie Indian used the travois summer and winter. Snowshoes were common everywhere. Summer travel was by canoe. The east coast tribes covered their canoes with moose hide, the woodlands people used birch-bark, and the west coast people made dugouts from their big trees. The birch-bark canoe was a dainty craft, light to handle in the

water and on the portage, but the Eskimo kyak probably required more skill to build and to use. It is as light as a canoe and almost unsinkable.

There were so few Indians and they used so few of Canada's resources that there was no need for them to practice conservation; but their poor tools made it necessary for them to help each other in the battle for food and shelter. They did most things cooperatively and so had the comfort of company in their hardships. The family was the unit of their social life. A few families of kinsfolk joined in a band and a number of bands made up a tribe. The natural products of the tribe's hunting-ground belonged to all in common. The fortunate hunter shared his game with all. The band feasted together and starved together.

When a child was born, the older women came to help the mother. If the baby fell ill, the medicine man charmed away the evil spirits. Indian parents seldom scolded their children and almost never struck them. They taught them to do the different kinds of work required, and in the evenings all drew round the fire to listen to the old men tell stories of the great deeds of their forefathers. At 13 the boy or girl spent a few days alone, fasting and hoping to dream of a good spirit who would come to guide his or her life. Young people married about 18. The groom paid for his bride with gifts to her parents. In the new home, the husband hunted, fished and made tools and utensils, while the wife brought in the meat and firewood, cooked dressed the skins, and made the clothing. She sewed the tent and canoe coverings, too, for the man must have his weapons always in his hand to kill game, or to protect his family.

Leisure hours were filled with wrestling, racing, spear throwing and games such as lacrosse, football and shinny which was usually played by

the women. Gambling and dancing were the most popular amusements.

The Indians were religious people. They believed that the natural objects and animals about them were inhabited by spirits, and their prayers, dances, feasts and ceromonies were performed to win the help of these spirits. The medicine men were their doctors and priests. All Indians seemed to have believed in heaven and placed food and weapons beside their dead to help them on their way to the Happy Hunting Grounds.

The red men were democratic. Among the woodland tribes each band chose as leader a man who was brave, or good, or a skillful hunter; but the others followed him only when they thought his plan a good one. They had no laws and no police. Good Indians did as their fathers had taught them, and the evil doer paid for his sins with gifts to the one he had wronged. Those who committed serious crimes were outlawed; the outlaw had to live alone and might be killed on sight.

The prairie tribes had advanced a step further. They were grouped into large bands, each governed by a council of its leading men with one acting as chief. Here again the power of the leaders depended upon the people, who obeyed them only as long as they respected, or feared them. Each summer, all the bands of a tribe met, chose their council and head chief, and spent two or three weeks in discussing the affairs of the tribe and in parties and dances. Later, four prairie tribes: Blackfoot, Blood, Piegan, Sarcee formed a confederacy which fought the Cree Confederacy for possession of the buffalo plains.

The farming tribes of the Iroquois Confederacy elected village councils of men and women to make rules and keep order in the community. Each tribe had also a council of leading men; and over the six tribes of the Confederacy

there was a League Council of several chiefs chosen to represent the tribes. The famous chief, Hiawatha, is believed to have organized the League Council.

Only the west coast tribes were divided into social classes. With them all the members of one family lived in the same plank house, but the people in the house were divided into slaves, commoners and nobles. A commoner would save for years to give one great feast in order to gain a higher social position. The slaves did the hard work of the house and the community.

The greatest gift that we owe to the red man is our broad land which they allowed us to take over without making any general war against us. Indeed our Indians seem to have been much less war-like than the story books and moving pictures make out. When the white folks came as immigrants and began taking their land from them, the Indians naturally tried to kill them and drive them away. This, with their painted faces and blood curdling war-whoops, made the early settlers think of them as frightful savages; but by far the largest part of Canada's dealing with them has been in the way of peaceful trade.

Some of the tribes were poor and wretched, but other were intelligent proud people. They gave us hundreds of musical place names for our country and added many useful words to our language. Their songs, dance rhythms, designs and coloring have enriched our arts; and they have left us one of the largest collections of myths and legends possessed by any nation. They have taught us also many practical things: to grow corn, potatoes, tobacco; to make maple sugar, and play lacrosse. Their trails, their inventions: the canoe, teepee, toboggan, and snowshoe; their ways of hunting, trapping,

travelling, making a fire and shelter, were adopted by the white man and were used by them in exploring and opening up our country. White men still use these gifts of the Indians, though they are seldom as skillful in doing so as their red brothers.

In return for these gifts the white man tried to Christianize the Indians, but did little towards civilizing them. Only in our own day has Canada begun to make citizens of her first settlers and fit them into the national life.

....

In those days, in spite of their many good points, the Canadian Indians were still nomads, wanderers and uncivilized people, although the people of Europe and Asia had long ago learned to farm. After thousands of years of hunting, some clever person thought of taming the wild horses, cattle, sheep and pigs, and the people became herdsmen. Probably more thousands of years passed before they began to cultivate the wild food grasses: wheat, oats, barley, rye. When they had done that, they became farmers. They ceased to be nomads and settled down in communities. Farming was the beginning of civilization for it tied man to one place. He learned to build a house and later towns and cities. There each person could work always at one trade and so become really skillful at it. It was in this way that people began to be civilized.

The first people who came to America were still hunters and nomads; they seemed to have left Asia before the people there learned to farm. They found no food grasses here except corn which grew wild in Central America, and wild rice which grew as far north as southern Canada. The tribes that settled in Central America and Mexico learned to cultivate corn. They became farmers

and built cities as the people of Asia had done. Slowly farming spread north to some of the tribes in what is now the United States and they also began to live more settled lives. But the kind of corn they had does not grow well in Canada, so the Canadian Indians remained hunters and nomads.

Because of being uncivilized, our Indians could not make use of Canada's good farm-land, nor of the other rich resources that nature had given her. To use these gifts, Canada needed civilized people, and they were already at her door.

SOCIAL STUDIES TEST III

____ 1. Iroquois village councils contained (a) only the old men (b) both men and women (c) only the chiefs (d) only men.

____ 2. Compared with the Eskimo kyak, the Indian's birch-bark canoe (a) required less skill to build and to use (b) required more skill to build, less to use (c) required more skill to build and to use (d) required more skill to use, less to build.

____ 3. The Indians of the plains learned that "in unity there is strength" since (a) they formed confederacies (b) they chose their own leaders (c) they always did as their fathers had taught them (d) they were nomads.

____ 4. The most popular amusements for the Indians were (a) gambling and lacrosse (b) lacrosse and dancing (c) gambling and dancing (d) wrestling and dancing.

____ 5. White men often use Indian devices (a) and are equally skillful with them (b) but are less skillful with them than the Indians (c) and are now more skillful with them than the Indians (d) and are just as skillful with them as the Indians.

____ 6. Conservation of natural resources is necessary (a) only when white men first come to an area (b) when a country is uncivilized (c) when large numbers of people use the natural resources (d) when people, like the Indians, depended upon nature for food, clothing and shelter.

____ 7. Tobacco was first grown in Canada by the (a) Iroquois (b) Cree

(c) Ojibways (d) Blackfoot.

____ 8. Compared with the Indians of story books and movies, real Indians were (a) much less savage and war-like (b) were much more backward in their way of life (c) were stronger and more clever (d) were much more savage and war-like.

____ 9. Civilization, as we know it, depends on (a) people being democratic (b) people learning how to domesticate animals (c) people being free to move from place to place (d) people living in communities.

____ 10. Totem poles were made by (a) Cree (b) Pacific Coast Indians (c) Hurons (d) Iroquois.

____ 11. In the battle for survival the Indians were forced to help one another because (a) the chiefs told them to work together (b) there were too many animals for one person to handle (c) their tools were poor (d) they did not know how to work alone.

____ 12. Before people could change from wandering to living in communities,they had to learn (a) to build houses (b) to tame wild animals (c) a trade of some kind (d) to cultivate the wild food grasses.

____ 13. The Indians of Mexico became farmers (a) long before the Indians of Canada (b) long after the Indians of Canada (c) about the same time as the Indians of Canada (d) none of these are true since there are no Indians in Mexico.

____ 14. If a commoner could put on a big feast he might become a noble in the (a) Iroquois tribes (b) Pacific Coast tribes (c) Cree tribes

(d) Huron tribes.

_____ 15. Aside from the fact that the Indians gave us the land of Canada, we would conclude that (a) the Indians made many noteworthy contributions to our way of life (b) the Indian had many things to offer the white man, but the whites could not use them (c) although in the early days the Indian helped the white man, none of these contributions remain today (d) the Indian contributed very little to our way of life.

_____ 16. In the fight for the buffalo plains the Blackfoot Confederacy fought against (a) the Coast tribes (b) the Iroquois (c) the Cree (d) the Hurons.

_____ 17. Because they believed in heaven, Indians (a) placed food and weapons beside their dead to help them (b) buried their dead (c) felt that natural objects were inhabited by spirits (d) went to the Happy Hunting Grounds.

_____ 18. Uncivilized people like the early Indians had to depend on getting their food, clothing and shelter from (a) the things they could steal from the settlers (b) travelling salesmen (c) the things nature provided around them (d) the supplies provided by the government.

_____ 19. The first Canadians used tools made chiefly from (a) bone (b) ivory (c) wood (d) stone.

_____ 20. The first people in America were nomads likely because (a) they wanted to see the new country (b) they left Asia before the people

there had learned to cultivate grain (c) they did not like farming (d) they were looking for a passage to the East.

____ 21. The stability or permanence of an Indian community depended upon (a) the nature of the people (b) the advice of the medicine man (c) the climate of the country (d) the availability of a food supply.

____ 22. In Indian tribes, medicine men were (a) doctors (b) priests (c) both of these (d) neither of these.

____ 23. The Indians did not use Canada's great resources effectively because (a) they did not want to settle down (b) they didn't need them (c) they were uncivilized (d) none of these reasons are true.

____ 24. The wigwam was invented by the Indian since (a) the only materials available were the skins of animals (b) there was little wood for houses (c) he wanted a permanent home (d) he needed a shelter that could be set up and taken down easily.

APPENDIX B

EXAMPLE OF READING SELECTION AND TESTS USED IN THE TRAINING PERIODS IN MATHEMATICS

ARITHMETIC IN BUSINESS

Mr. Goodman operates a shoe store. When he buys shoes from a manufacturer, he must sell them above cost in order to pay the expenses of operating the store and to make a profit or gain. The amount that he marks the price of shoes above what they cost him is called the mark-up. The mark-up may be expressed either as a per cent of the cost or as a percent of the selling price. The selling price is the amount that the customer pays for an article.

Suppose that Mr. Goodman pays $4 for a pair of shoes and sells them for $6 a pair. We can see that the mark-up is $6 - $4, which is $2. This mark-up may then be expressed in two ways:

(a) as a percent of the selling price -

$2 is what percent of $6

$\$2 = ?\%$ of $\$6$

$$\frac{2}{6} = \frac{1}{3} = 33\frac{1}{3}\%$$

The mark-up is $33\frac{1}{3}\%$ of the selling price.

(b) as a percent of the cost -

$\$2 = ?\ \%$ of $\$4$

$$\frac{2}{4} = \frac{1}{2} = 50\ \%$$

The mark-up is 50 % of the cost.

In order to attract customers to his store or to encourage more sales,

it is sometimes necessary for a merchant to mark down the former price of an article. The amount that an article is reduced in price from its former price is called the reduction. The percent of reduction is the reduction compared with the former price.

Mr. Goodman had a pair of shoes that he originally wanted to sell for $15 reduced in price to $12. In this case the reduction is $15 - $12 = $3. Expressed as a percent of the former price, this reduction is

$$\frac{\$3}{\$15} = \frac{1}{5} = 0.20 = 20\%$$

When Mr. Goodman orders shoes for his store, he consults a catalogue which gives wholesale prices. A wholesale dealer buys and sells only in large quantities and usually sells to other merchants or retailers.

The catalogue price, or list price, is more than Mr. Goodman will have to pay. The wholesale dealer gives a reduction or a discount on the list price. The reduction in price of an article to a dealer is known as a trade discount. Thus "40% off" in the cost of a pair of shoes means that the net cost to Mr. Goodman is 40% less than the catalogue price.

Let us imagine that a pair of shoes is listed in the catalogue at $7.50. If a trade discount of 40% is given, we can find the net cost as follows:

List price = $7.50
Rate of discount = 40%
Net cost = ?

Net cost = list price - discount
Discount = 40% of $7.50
Discount = .40 x $7.50 = $3.00

Net cost - $7.50 - $3.00 = $4.50

The net cost is $4.50.

Suppose a boy buys newspapers at the rate of $3.00 for 100 papers and sells them at 5 cents each. His mark-up on each paper is 2 cents. If he

sells an average of 80 papers a day, he makes a profit of $1.60

In running a business like that of selling papers, there are no expenses; therefore, the difference between the selling price and the cost of the papers the boy sells is all profit. Profit, in this kind of business is the difference between the money received in payment and the money paid out.

Another boy has a soft drink stand. He buys soft drinks from the manufacturer at 80 cents a case of 24 bottles and sells them at 5 cents a bottle. The difference between the cost and the selling price of a case of drinks is 40 cents. In this instance, the mark-up is not all profit for the boy has some expense in operating the soft drink stand. He must pay rent for his stand, buy ice to keep the drinks cold and advertise to attract people. In this case profit is the difference between mark-up and expenses. When the expenses are greater than the mark-up it is known as a loss.

TEST NUMBER THREE

ARITHMETIC IN BUSINESS

(FACT)

_____ 1. The selling price of an article is made up of (a) the cost plus expenses (b) the cost plus mark-up (c) the mark-up alone (d) the cost minus the mark-up.

_____ 2. The mark-up may be expressed as a percent of (a) the selling price (b) the cost (c) either of these (d) neither of these.

_____ 3. The amount the price of an article is lowered by a store-keeper is called (a) the sale (b) the mark-down (c) the reduction (d) the net price.

_____ 4. The percentage of reduction is (a) the reduction compared with the former price (b) the reduction compared with the reduced price (c) the reduction compared with the list price (d) the reduction compared with the mark-up.

_____ 5. A merchant usually buys his merchandise from (a) a retailer (b) a wholesaler (c) a factory (d) none of these are correct.

_____ 6. The reduction in price of an article to a dealer is called (a) the net cost (b) the list price (c) the mark-up (d) a trade discount.

_____ 7. The net cost of an article to a dealer is (a) list price - discount (b) selling price - discount (c) list price + mark-up (d) list price + discount.

_____ 8. The mark-up is (a) selling price - expenses (b) cost - expenses (c) selling price + expenses (d) selling price - cost.

_____ 9. In some business profit is the same as (a) expenses (b) discount (c) mark-up (d) selling price.

_____ 10. When expenses are greater than mark=up, a business is said to operate at a (a) reduction (b) loss (c) profit (d) discount.

TEST NUMBER THREE

ARITHMETIC IN BUSINESS

(RELATIONSHIPS)

____ 1. The selling price of an article is made up of (a) cost plus mark-up (b) the mark-up alone (c) cost minus mark-up (d) cost minus expenses.

____ 2. In order to cover operating expenses and make a profit (a) the selling price must be greater than the expenses (b) the mark-up must be greater than the cost (c) the mark-up must be greater than the selling price (d) the selling price must be greater than the cost.

____ 3. A merchant may reduce the selling price of an article (a) because he is generous (b) because the goods are inferior (c) to attract customers to his store (d) none of these reasons are sound.

____ 4. A wholesale dealer can offer a trade discount because (a) he sells only to retailers (b) he sells only large quantities which require less handling (c) wholesalers always have sales (d) he is trying to encourage more sales.

____ 5. A house-to-house salesman could sell an article more cheaply than a store-keeper could because (a) he sells more articles (b) he has fewer expenses (c) his articles are always inferior (d) none of these are true.

____ 6. Because a man has no expenses in selling papers, (a) profit is equal to the difference between selling price and cost (b) profit is

equal to mark-up (c) profit is the difference between money received in payment and money paid out (d) all of these are true.

______7. A store-keeper has many expenses in operating his store. In this case (a) profit is equal to the difference between mark-up and expenses (b) profit is equal to the mark-up (c) profit is equal to the difference between the selling price and the cost (d) profit is equal to the difference between the mark-up and the selling price.

_____ 8. A loss occurs in a business (a) when the mark-up exceeds the expenses (b) when the mark-up exceeds the cost (c) when the expenses are greater than the mark-up (d) when any of these occur.

_____ 9. When a businessman reduces the selling price of goods, the percentage of reduction is the reduction compared with (a) the cost price (b) the reduced selling price (c) the former price (d) the mark-up.

_____ 10. The net cost of articles from the wholesaler is (a) less than the list price (b) equal to the list price (c) greater than the list price (d) equal to the merchant's selling price.

TEST NUMBER THREE

ARITHMETIC IN BUSINESS

(GENERALIZATIONS)

_____1. If a man operating a hardware store buys a stove for $200 and sells it for $250, the mark-up would be (a) 25% (b) 20% (c) either of these (d) neither of these.

_____2. A manufacturer sells an article to a store-keeper for $6 and the store-keeper sells it for $8. Compared with the selling price, the store-keeper's mark-up is (a) 25% (b) 33 1/3% (c) 75% (d) none of these are correct.

_____3. If a TV salesman sells a set for $300 and the set cost him $250, the mark-up, compared with the cost, is (a) 16 2/3% (b) 83½% (c) 20% (d) 33 1/3%.

_____4. If a shoe salesman marks-up shoes 20% of the selling price, a pair of shoes that sold for $20 would cost (a) $4 (b) $16 (c) $24 (d) none of these are correct.

_____5. Suppose a shop-keeper held a sale at which he advertised that a certain article would be selling at a reduction of 10%. If the original price of the article was $25, the reduced price would be (a) $22.50 (b) $15 (c) $2.50 (d) $24.75.

_____6. An article is in a wholesale catalogue at $20 and a store-keeper can buy it for $15. The trade discount is (a) 33 1/3% (b) 25% (c) 5% (d) 75%.

_____ 7. An article is in a wholesale catalogue with a trade discount of 30%. The net cost of this article to a retailer is (a) $19.50 (b) $4.50 (c) $14.55 (d) $10.50.

_____ 8. A door-to-door salesman who has no operating expenses, buys articles at 10 cents each and sells them at 15 cents each. If he sold 200 of these articles, his profit would be (a) $20 (b) $10 (c) $30 (d) none of these are correct.

_____ 9. Suppose a washing machine costs a merchant $300 and he sells it for $350. He estimates that in selling each washing machine there is a total expense involved of $60 including advertising, rent, lights, salesman's wages, etc. According to this, the merchant (a) made a profit of $5 on each machine sold (b) made a profit of $55 on each machine sold (c) broke even on each machine sold (d) suffered a loss of $5 on each machine sold.

_____ 10. In order to make a profit, the operator of a store must be sure that (a) his mark-up is greater than his expenses (b) his mark-up covers the cost of the articles he sells (c) the mark-up equals the expenses (d) his mark-up does not exceed his expenses.

APPENDIX C

EXAMPLE OF LESSON PLANS

USED IN THE TRAINING PERIODS IN SCIENCE

LESSON #3

Winds - Fact

Stage 1 : Read over the selection "winds".

Time: 3 minutes.

Stage 2: We have been reading material carefully and marking the important facts in order to learn and remember as much of a selection as possible. Let's go over this selection just as we did the other two.

1. How are winds regarded by men who study weather? (They are considered to be a very important part of weather.)
2. What is wind? (Wind is air moving horizontally.)
3. When air is moving up and down what is it called? (A current of air.)
4. What is the cause of wind? (Wind is caused by differences in air pressure.)
5. Which way do winds blow? (From regions of high pressure to regions of low pressure.)
6. What does air do when it is heated? (Air expands when it is heated.)
7. In what direction does a lake breeze blow? (From the lake to the land.)
8. What are local winds? (They are winds caused by local conditions.)
9. Name five local winds. (Lake breezes, land breezes, sea gusts, gusts from thunderstorms, winds from forest fires.)
10. What is a high? (A great movement of air out in all directions from a region of high pressure.)

11. What is a low? (A great movement of air, in from all directions to a region of low pressure.)

12. Canada is in what wind zone? (The belt of Westerlies.)

13. In what direction do winds most frequently blow in Canada? (From the west.)

14. What is a cyclone? (A great swirl of air moving across the country. It is another name for a low.)

15. A high is also called what? (An anticyclone.)

16. In what direction do highs and lows move across Canada? (They move from west to east.)

17. What use do meteorologists make of information about highs and lows? (It is used for the prediction of wind velocity and direction.)

Time: 15 minutes.

Stage 3: Now that we have marked the important facts in this selection, re-read it, noting these facts carefully as you read. After you have read the selection there will be a short test to see how much you have learned.

Time: 3 minutes.

Stage 4: Multiple-choice test on the facts of the selection.

Time: 8 minutes.

Stage 5: The tests will be corrected by the students and the experimenter.

Time: 5 minutes.

LESSON #3

Winds - Relationships

Stage 1: Read over the selection "Winds".

Time: 3 minutes.

Stage 2: We have been reading material carefully and marking the important relationships that are found in a selection. Let us proceed to do the same thing with this selection.

1. How may "Winds" and "currents of air" be compared?
    (a) They are alike in that they are both moving air.
    (b) They are different in that wind moves horizontally and currents of air move vertically.
2. What is the cause of winds? (Differences in air pressure cause winds.)
3. A very strong wind is the result of what conditions? (The difference in pressure is very great.)
4. What is the effect of the sun on the land around a lake? (The land becomes hotter than the water.)
5. How does this influence the air? (The air over the land becomes warmer than the air over the water.)
6. What is the result when air is heated? (It expands.)
7. How would a given volume of cold air compare with the same volume of warm air? (The cold air would be heavier.)
8. What effect does the expansion of the air over the land have on the air pressure? (The air pressure decreases over the land.)
9. How may land and water be compared as far as rates of cooling are concerned? (Land cools faster than water.)

10. How are lake breezes, wind from forest fires and sea gusts similar? (They are all caused by local conditions or are local winds.)

11. How may "highs" and "lows" be compared?
    (a) They are alike in that they are both disturbances in the general movement of air.
    (b) They are different in that highs are movements of air out from regions of high pressure and lows are movements of air into regions of low pressure.

12. What causes our country to be described as being in the "belt of westerlies"? (The movement of air is from the west a large part of the time.)

13. In what ways are "lows" and "cyclones" similar? (They are two names for the same thing.)

14. What results from the forecaster's study of the highs and lows? (He can predict wind velocity and direction.)

Time: 15 minutes.

Stage 3: Now that we have marked the important relationships in this selection, re-read it, noting these relationships carefully as you read. After you have read the selection there will be a short test to see how much you have learned.

Time: 3 minutes.

Stage 4: Multiple-choice test on the relationships of the selection.

Time: 8 minutes.

Stage 5: The test will be corrected by the students and the experimenter.

Time: 5 minutes.

LESSON #3

Winds - Generalizations

Stage 1: Read over the selection "Winds".

Time: 3 minutes.

Stage 2: We have been reading material carefully and noting the important conclusions that may be made from the selection and the reasons for reaching these conclusions. By using this method we hope to learn and remember more about the things we study. Let us re-read this selection just as we have done the others.

1. The first important conclusion in the selection is that wind is caused by differences in air pressure. Although there is no direct evidence to support this in the selection, how do you suppose scientists might arrive at this conclusion? (By observing winds and noting conditions of pressure.)
2. What conclusions have been reached about the directions that winds blow? (Winds blow from regions of high pressure to those of low pressure.) Although there is no real support for this in the selection we can see how it is used. If the air pressure at a place A is very much greater than it is at another place B, what can we say about the movement of air? (A strong wind will blow from A to B.)
3. Why have scientists come to expect breezes to blow from a lake to the land on a hot summer day? (Land heats fastest, air over land heats, expands, reduces pressure, wind blows.)
4. From the material studied, what can be concluded about the rate of heating of land, air and water? (Land heats fastest, water next fastest and air least rapidly.) Can this be made more general - that is, does

it apply to all solids, liquids and gases? (Yes, it does.)

5. According to this selection, what conclusions may be drawn about the heating and cooling of materials? (Substances that heat rapidly, cool rapidly.)
6. To understand winds other than local winds, what must scientists know? (They must know of the procession of highs and lows across a country.) Why is this important? (They cause the winds.)
7. What led scientists to conclude that our country is in the "belt of westerlies"? (The general movement of air across Canada is from the west - there is a constant procession of highs and lows across the country from west to east.)
8. Why does a study of the highs and lows enable a forecaster to predict wind velocity and direction? (Differences cause wind, degree of difference determines velocity.)
9. After reading the whole selection what would be a good definition of a wind? (Horizontal movement of air caused by differences in air pressure.)

Time: 15 minutes.

Stage 3: Now that we have marked the important conclusions in this selection, re-read it, noting these conclusions carefully as you read. After you have read the selection there will be a short test to see how much you have learned.

Time: 3 minutes.

Stage 4: Multiple-choice test on the generalizations of the selections.

Time: 8 minutes.

Stage 5: The tests will be corrected by the students and the experimenter.

Time: 5 minutes.

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